

CANADA
DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

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THE NORTHERN RED-BACKED MOUSE,
Clethrionomys rutilus (Pallas), IN CANADA

BY
T. H. Manning

1956

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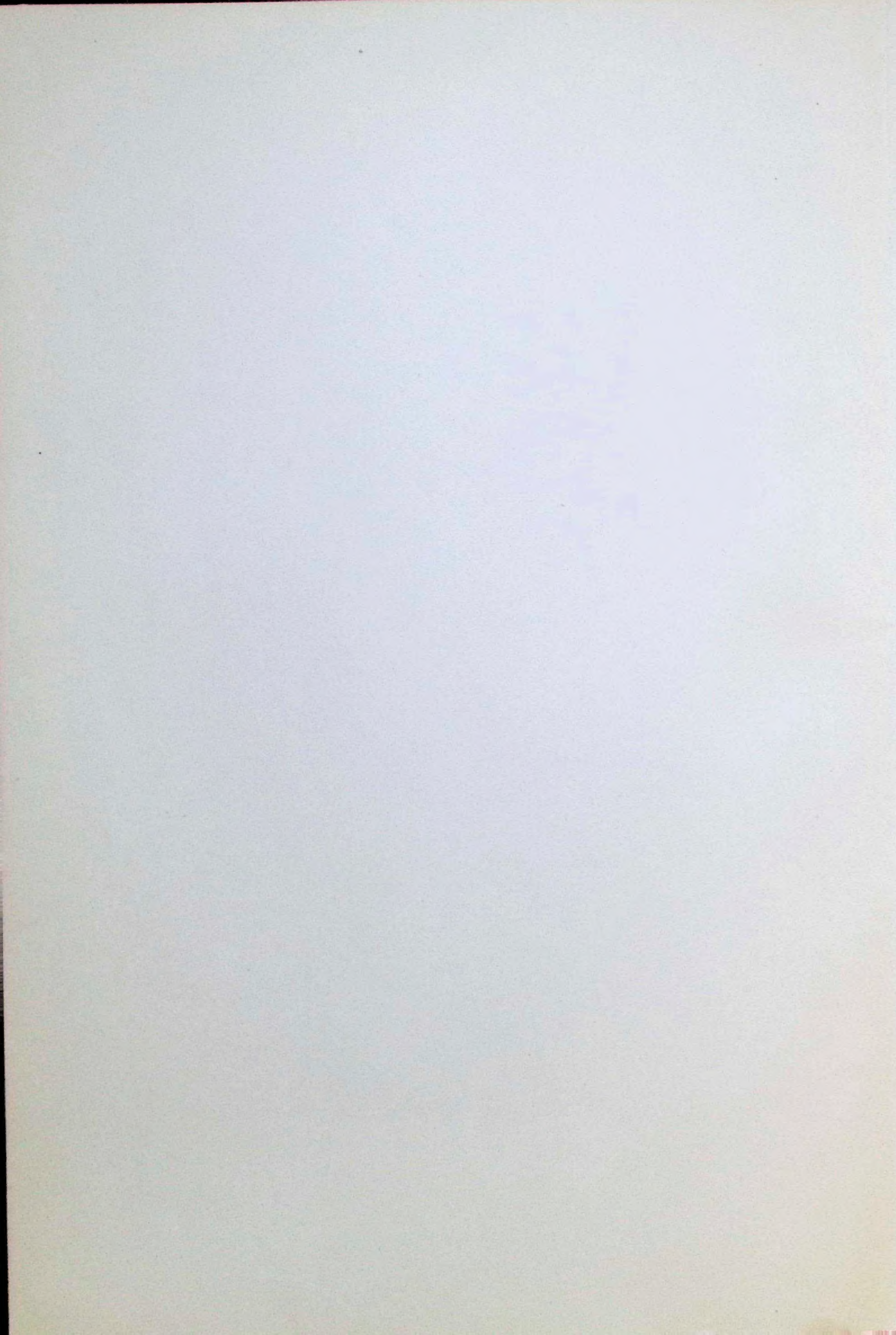
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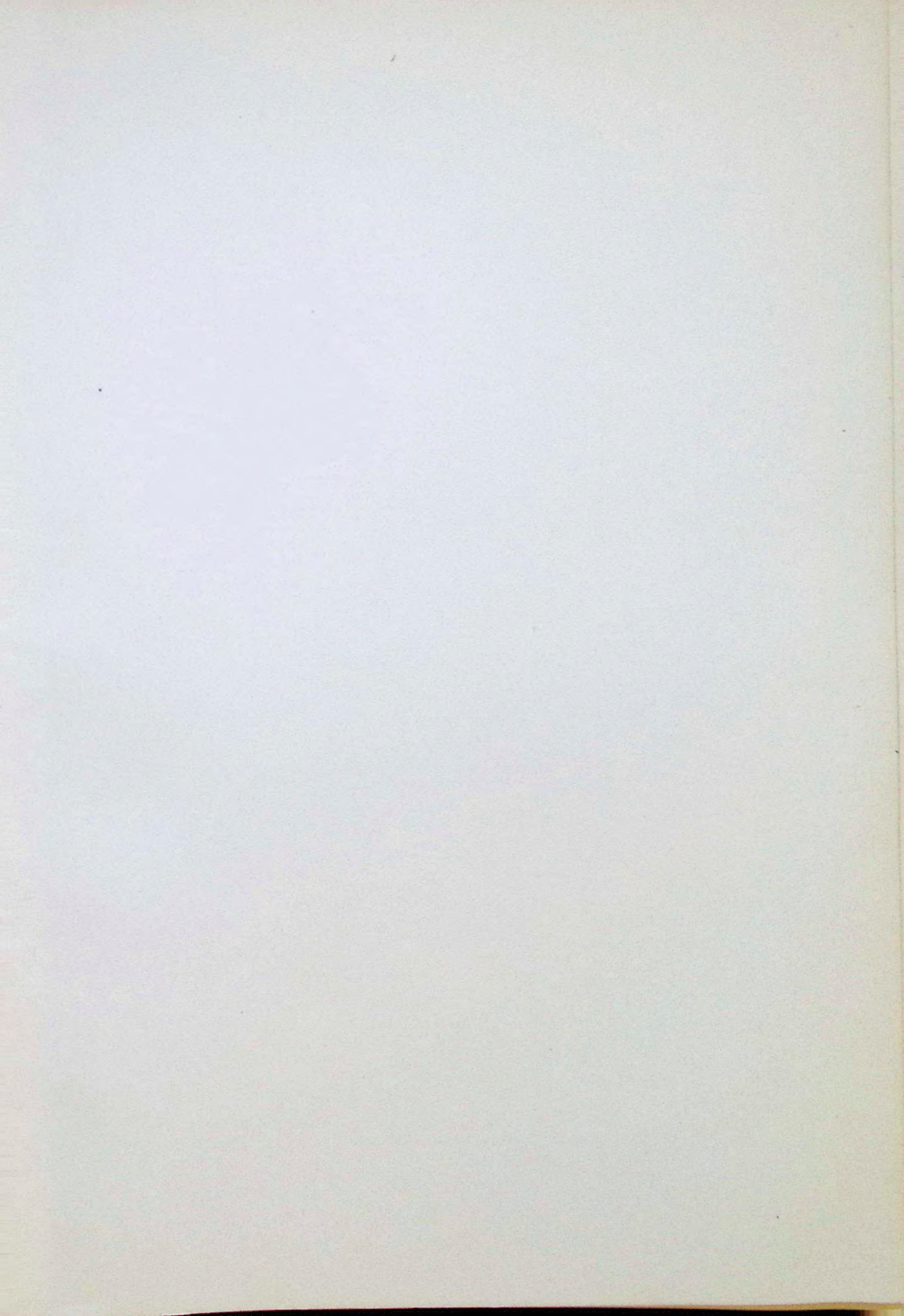
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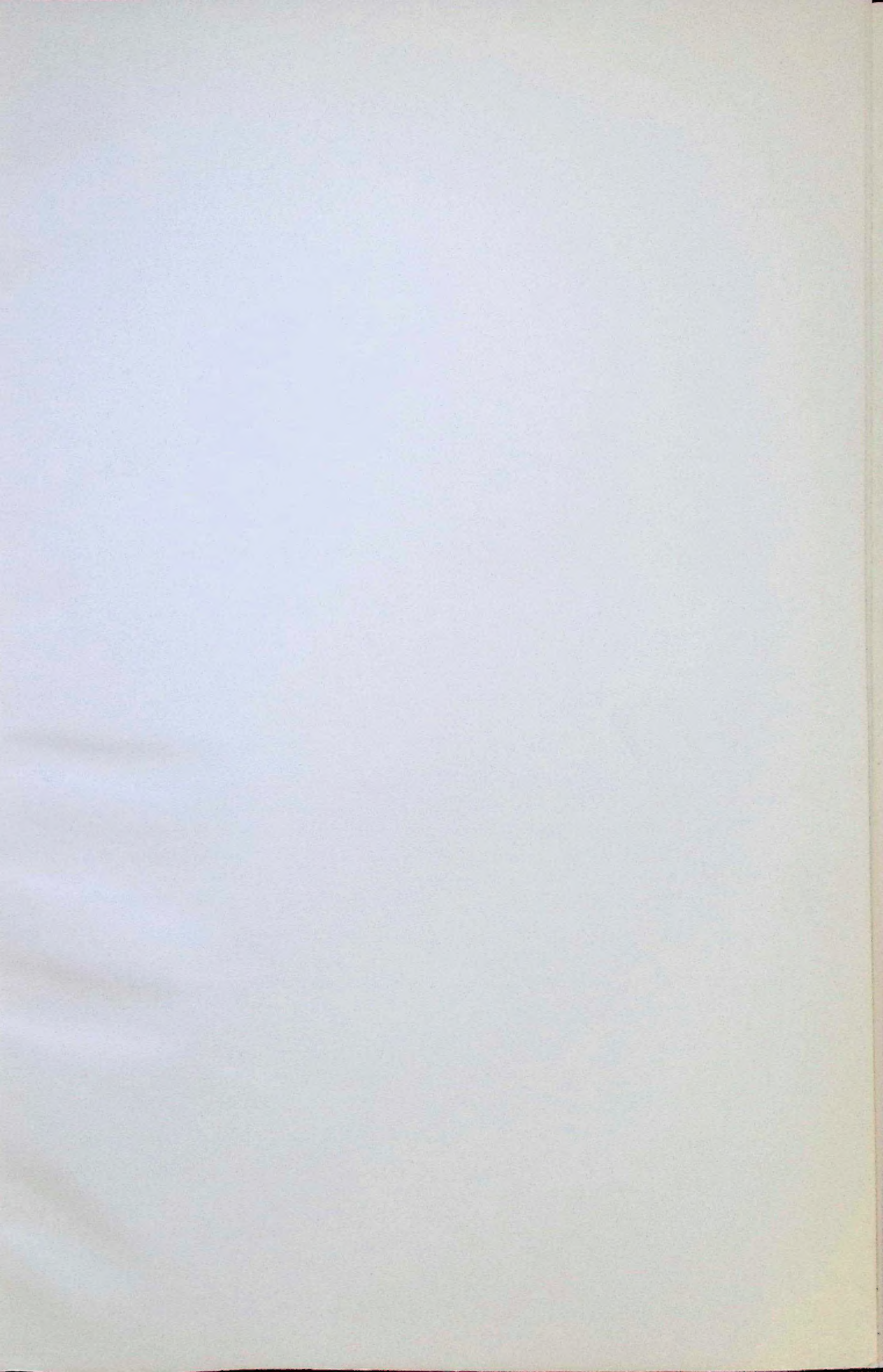
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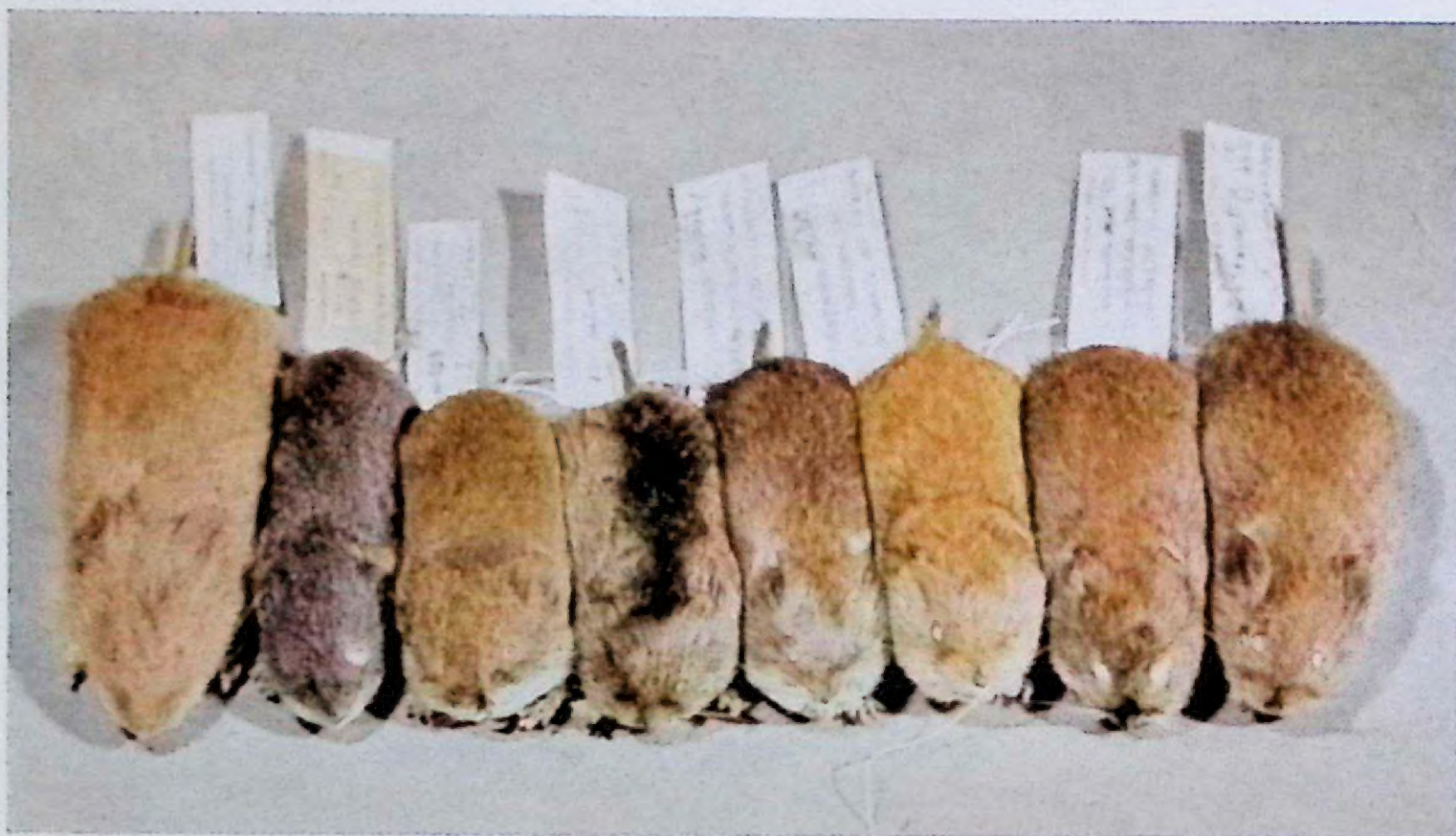
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Left to right:

U.B.C. 2885. ♂. Pale-phased or aberrant *C.r. dawsoni*. Taken 9 miles north of Aklavik, June 13, 1947.

A.M.N.H. 29134. ♀. Juvenal *C.r. washburni* with worn peltage. Taken at Aylmer Lake, August 17, 1907.

N.M.C. 18856. ♀. Juvenal *C.r. dawsoni* with worn peltage. Taken at Victory Lake, August 11, 1945.

N.M.C. 20738. ♀. Dark-phased *C.r. dawsoni*. Taken at Aklavik, September 11, 1951.

N.M.C. 20931. ♂. Winter peltage, grade 6. Taken at Tuktoyaktuk, October 20-29, 1952.

N.M.C. 20768. ♀. Winter peltage, grade 1, *C.r. dawsoni*. Taken at Aklavik, November 18, 1952.

N.M.C. 21358. ♂. Summer *C.r. washburni*. Taken on August 31, 1948, at Clinton-Colden Lake.

N.M.C. 17331. ♀. Summer *C.r. dawsoni*. Taken at Haines Road Junction, July 22, 1943.

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NATIONAL MUSEUM OF CANADA

THE NORTHERN RED-BACKED MOUSE,
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BY
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E R R A T A

- p. 19 and elsewhere. For "pellage" read "pelage".
- p. 29, Fig. 6. For "triangles" read "rectangles".
- p. 42, 3 lines up. For $Sd_y^2 - Sd_{xy}d_y$ read $Sd_y^2 - 2Sd_{xy}d_y$.
- p. 54, 21 lines up. For "race" read "species".

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THE NORTHERN
RED-BACKED MOUSE, *Clethrionomys rutilus* (Pallas),
IN CANADA¹

INTRODUCTION AND ACKNOWLEDGMENTS

This paper is primarily a taxonomic study of the Arctic Red-backed Mouse, *Clethrionomys rutilus*, in Canada, based on collections made at Tuktoyaktuk, Aklavik, and Norman Wells in 1951 and 1952, on other specimens in the National Museum, and on material borrowed from the American Museum of Natural History, the Chicago Museum of Natural History, the Royal Ontario Museum, the United States National Museum, the University of British Columbia, and the University of Kansas². No attempt has been made to gather sufficient material for a detailed study of the Alaskan populations, and the races of *C. rutilus* occupying southeastern Alaska are definitely outside the scope of the paper. However, in an attempt to clarify the relationship of the nearctic and palaeartic populations, a series of skins and skulls of *C.r. jochelsoni* from eastern Siberia has been examined and measured.

The non-taxonomic problems considered in this paper are a by-product of the taxonomic study, and in most cases final answers cannot be expected without laboratory and field work specifically directed to their solution. By putting forward some hypotheses on the basis of rather flimsy evidence, it is hoped that further work will be stimulated, or at least that future collectors may be induced to record relevant data. Some of the discussion has a definite bearing on the taxonomic problems and illustrates the difficulties of comparing measurements of skulls of a fast-growing, short-lived, cyclic animal.

Before beginning the consideration of growth and breeding biology, it is necessary to anticipate the taxonomic discussion to the extent of stating that the populations considered may be divided into two groups on the basis of skull height measured through the auditory bulla. Belonging to group I are the Siberian population, *C.r. jochelsoni*, and the population of Tuktoyaktuk and its environs. The other group occupies the remaining part of the Canadian range of the species. Within that area it can be broken down into two rather ill-defined races, *C.r. dawsoni* and *C.r. washburni*, with the possibility of a further division when more material is available. Although the two main groups are here considered conspecific, their precise relationship remains uncertain, and there may be differences in their breeding biology, growth, and ageing rates which would not be expected between the closely related subspecies making up the two groups.

¹This work was done under grants from the National Museum and Northern Research Coordination Centre of the Department of Northern Affairs and National Resources. I am indebted to Mrs. T. H. Manning for typing the manuscript and checking the calculations, to Mr. John Crosby and to Mr. T. R. Haldorsen of the National Museum for assisting with the graphs and map, and to Mr. Dalton Muir of the National Film Board for taking the coloured photograph.

²I wish to thank those responsible for the collections of mammals at these institutions for their generosity in lending specimens and in permitting their retention through several interruptions in the study. I am particularly grateful to T. Donald Carter, I. McTaggart Cowan, S. C. Downing, George G. Goodwin, E. Raymond Hall, C. O. Handley, David H. Johnson, R. L. Peterson, and Colin C. Sanborn.

FIELD WORK

In 1951 and 1952, Mr. Andrew Macpherson and I made the following collections of the Northern Red-backed Mouse, *Clethrionomys rutilus* (Pallas), while awaiting transportation on the return journey from two Defence Research Board expeditions:

Tuktoyaktuk	Sept. 21-24, 1951	4 ♂♂, 4 ♀♀
	Oct. 2-Nov. 8, 1952	60 ♂♂, 48 ♀♀, 1 (sex ?)
Aklavik	Sept. 27-29, 1951	8 ♂♂, 7 ♀♀
	Nov. 16-23, 1952	23 ♂♂, 37 ♀♀, 1 (sex ?)
Norman Wells	Nov. 24, 1952	8 ♂♂, 6 ♀♀

The 1951 Tuktoyaktuk collection was obtained from Eskimos who caught the mice in or near their houses. About a third of the 1952 collection was caught by us within the settlement, another third from the surrounding barrens a quarter of a mile to three miles from the settlement, and the final third, which was obtained from the Eskimos, came largely from within or just outside their houses. The number of traps we had out varied somewhat from day to day; the average was around twenty-five. It can be seen from the scatter diagram (Figure 2) that the catch fell off greatly toward the end of our stay. The Eskimos had by then probably trapped out their houses, while the apparent disappearance of mice from the surrounding country was caused, at least in part, by cold, windy weather, and deep snow. A few tracks, running for a short distance between holes, could be seen on the snow surface, but as soon as we put traps in these runways, drifting snow would cover them, and when fine weather again brought the mice to the surface, they came up through new holes and made new runways. Between November 8 and 12, when we finally picked up the traps, no mice were caught. I feel fairly certain that Red-backed Mice were less plentiful at Tuktoyaktuk in 1951 than in 1952. In the former year a few traps set by us in the settlement were unproductive, partly, perhaps, because of bad weather, and Tundra Mice, *Microtus oeconomus*, outnumbered Red-backed Mice in the catch brought in by the Eskimos, a situation which was reversed in 1952.

When we were at Aklavik in 1951, there was no appreciable snow, and the mice were obtained from 14 traps set in deciduous scrub at the outskirts of the town. In 1952, heavy snow made such trapping unprofitable, and nearly all the Red-backed Mice were caught at or near the town garbage dump, where they were very numerous. The 61 specimens were obtained in about 140 trap-day-nights with visits two or three times each day.

The Norman Wells specimens, which were also taken at the garbage dump, were obtained with 22 traps in an afternoon and night. In the following spring when I again passed through Norman Wells, May 7-10, mice appeared much scarcer. Only one Red-backed Mouse was obtained in 12 trap days and 6 trap nights.

This scarcity was no doubt caused partly by the normal winter deaths and partly by the burning of portions of the garbage dump.

DETERMINATION OF AGE BY SKULL CHARACTERS

Size, extent to which the sutures have closed, and the development of ridges and angularities assist in determining the age of Red-backed Mouse skulls. However, rapidity of growth probably varies with the season in which the young are born, and the apparent openness of the sutures is

affected by the method of cleaning and the period the skulls have been left in chemical bleaches. There is some apparent individual, and possibly geographical, variation in the development of ridges and angularity. Another and more useful criterion of age is the external evidence of the development of molar roots. As can be seen from the occasional loose molar, rooting begins long before it can be recognized externally, and it would be an obvious advantage if a molar, say m1, which first shows external evidence of root development, were removed and separately mounted when the skull is cleaned. As this had not been done in any of the material examined, and is not likely to be done in future general purpose museum material, molars which showed no outward evidence of roots are classed as unrooted, and the expression 'rooted molars' means that m1 not only has started to root, but has grown since rooting until its altered form can be seen above the alveolus. Prior to this, some indication of the mouse's age may be obtained from the size of the alveolar capsule above M2, for by the time rooting is first visible in m1, this capsule is reduced to about half its original size.

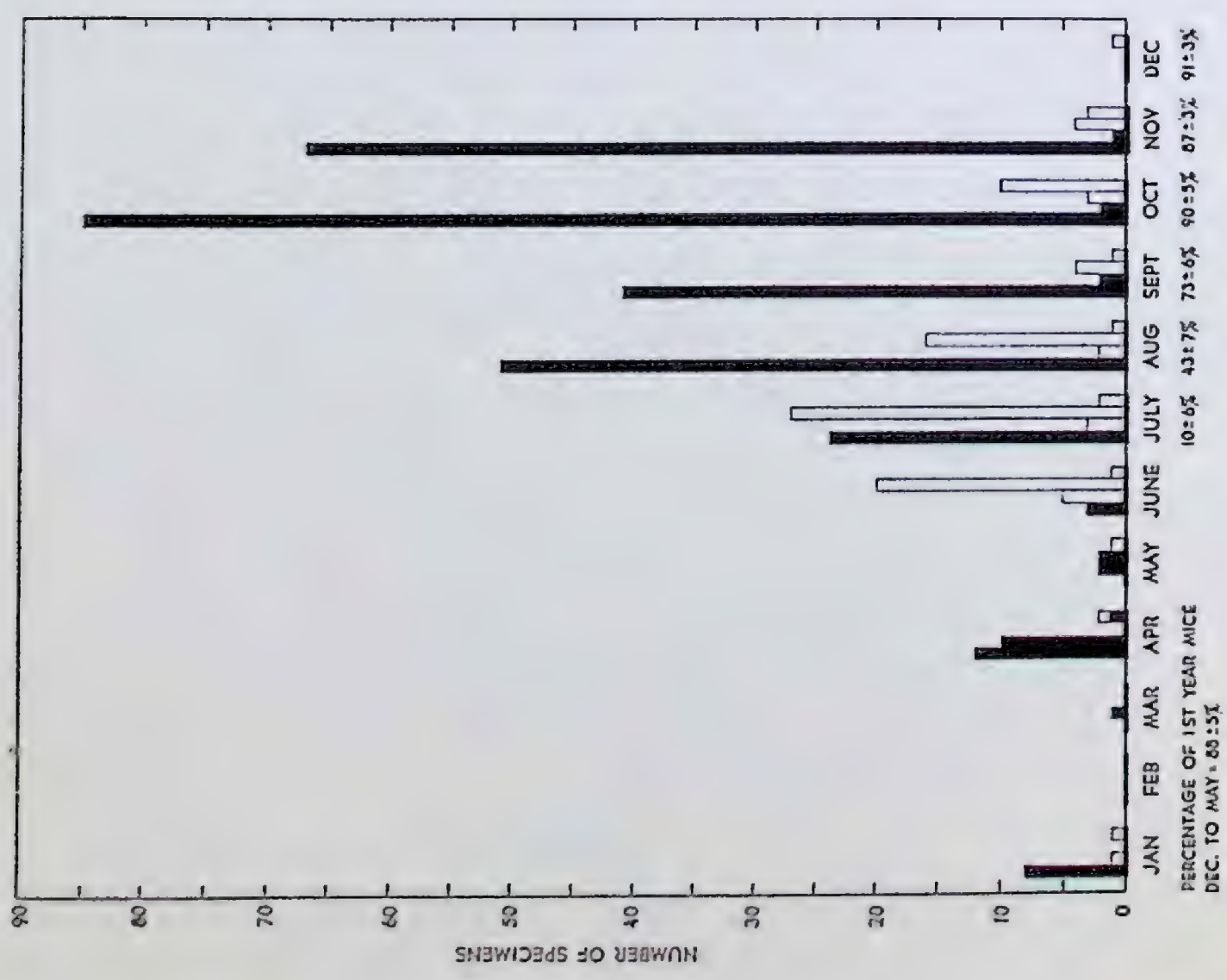
Razorenova (1952) relies principally on the gradual absorption of the alveolar capsules above M1 and M2 to distinguish three age groups in *C. glareolus*, *C. rufocanus*, and *C. rutilus*. In group I, the capsule is fully developed; in group II, it has been reduced to a small osseous callus, but the prisms of the teeth still reach the edge of the alveoli; in group III, the callus has disappeared, and the bottom of the orbit is concave, while in most specimens the roots of the teeth protrude from the alveoli. Unfortunately Razorenova's paper was not seen until the present work was almost completed. However, I have looked back at some of the nearctic skulls, and at least in these there is usually a remnant or scar from the alveolar capsule of M2 even when the teeth have begun to show wear. Also, there is seldom any appreciable concavity on the upper surface of the maxilla. The transition from a fully developed capsule to a mere remnant does not appear to be rapid, and it might not be easy to correctly assign specimens to groups I and II. Probably Razorenova's criteria are best adapted to *C. glareolus* and *C. rufocanus*, which species he considers more thoroughly. He does not assign any actual age to his groups, give the periods of the year in which the different groups predominated, or, at least for *C. rutilus*, give actual measurements of the age variations in skull shape that he records.

According to Ognev (1950, p. 116), the cheek teeth of *C. rutilus* root later than those of *C. glareolus* but earlier than those of *C. rufocanus*, although the actual age at which rooting occurs does not appear to be known for either species and can be determined with certainty only by breeding animals in captivity. Moreover, since the breeding season under natural conditions is believed to last for only four months (See p. 7), whereas mice with teeth just beginning to root may be taken in almost any month (See Table I), there is an apparent individual variation of about six months in the age at which molar rooting begins. This cannot be accounted for by variation between races, and the most reasonable explanation appears to be that molar rooting is associated with time elapsed since sexual maturity rather than with absolute age, so that animals maturing during their first summer may develop rooted teeth at an earlier age than those wintering as subadults. In a few instances it may possibly be due to mice having been born in houses during the winter (See footnote, p. 5). In spite of this, it appears possible to separate accurately at least 95 per cent

Figure 1. Variation in molar rooting by months.

The first bar for each month represents the number of skulls with no external evidence of rooted molars; the second bar, the number in which m1 can just be recognized as rooted (this is a transitory phase, and therefore the number of specimens is small); the third bar, the number which is more definitely rooted; and the fourth, those which are both rooted and worn.

Mice in their first year (commencing on June 1) are represented by solid bars, and the percentage of these to the total catch is given below each month. Standard deviations are given as a general guide only, and it must be remembered that the figures are derived from collections made in different years and in different regions, yet strongly biased by the large 1952 Tuktoyaktuk and Aklavik catch and the moderately large 1944 Canol Road catch. Moreover, except for the Tuktoyaktuk and Aklavik collections, there is no guarantee that collectors, having caught more mice than they could preserve, did not discard the smaller animals, thus destroying all claim for the collection to represent the population. A few specimens may have been incorrectly aged, particular doubt being attached to the two April and one May skulls with worn (one in each month very worn) molars. The number of specimens taken in different months is controlled largely by the extent to which collectors have operated at different seasons.



of young of the year from older individuals by the extent to which the molars have or have not rooted, and Figure 1 shows how the proportion of young of the year to older individuals builds up after June. All three June specimens with unrooted teeth (Figure 1) are young of the year, although the presence of some individuals with barely rooted teeth in the July and August collections suggests that some second year June mice with unrooted teeth would be found in a larger series. Indeed, there is a suspicion that the pregnant female with unrooted teeth, U.B.C. 2297, taken on July 10, is a second year mouse (See p. 12). There is little difference in alveolar capsule size between the April specimens with rooted and those with barely rooted molars, and both are undoubtedly young of the preceding summer. The two April and one May mice with worn molars (one in each month extremely worn) may be entering a third summer, but this is by no means certain, and it is thought improbable that any June or later summer specimen has passed through more than one winter. A similar opinion is given by Brambell and Rowlands (1936, p. 76) for *C. glareolus*, and Baker and Ranson (1933, pp. 488-491) for *Microtus agrestis*.

BREEDING SEASON LIMITS AND LITTER FREQUENCY

It seems unlikely that *C. rutilus*, which occupies the arctic and sub-arctic range of the genus, ever breeds throughout the winter under natural conditions¹, although it appears that in some years *C. glareolus* may do so in the more equable climate of southern Britain (Brambell and Rowlands, 1936, p. 77). In 1941, Morris (1955, p. 28) found *C. gapperi* breeding in eastern Canada from about mid-May to mid-October. In Ontario, Coventry (1937, p. 492) recorded 30 per cent of females pregnant as late as mid-September, and in northeastern New York, Merriam (1884, p. 174) recorded pregnant females as early as April 3 and as late as October 4. The vulva of most of the females taken at Tuktoyaktuk and Aklavik in October and November, 1952, was examined. In only three specimens was it open, and even in these, perforation may have been caused by slight tainting while the carcass was thawing. The approximate (i.e., measured with mm. ruler) testis lengths of two males taken at Tuktoyaktuk and one taken at Aklavik were as follows: N.M.C. 20815, October 2, condylobasal length, 21.9 mm., testis, 2.8 mm.; N.M.C. 20816, October 2, condylobasal length, 22.3 mm., testis, 3.5 mm.; N.M.C. 20741, November 16, condylobasal length, 23.0 mm., testis, 3.0 mm. The dried skins of mice taken in October and November, 1952, and between September 21 and 29, 1951, show no evidence of enlarged mammae nor of the worn underparts usually associated with nursing females, nor has evidence of nursing been found in any other skins with winter peltage.

The earliest spring record for young Arctic Red-backed Mice found in the literature or on the labels of the specimens examined (See Table I) is June 3, when Porsild (1945) took a female with five suckling young at Reindeer Station. Rand (1945) gives the date for the first young trapped on the Canol Road in 1944 as June 20, but a skin (N.M.C. 17661, skull

¹Speaking of *C.r. joehelsoni* (= *Evotomys vosnessenskii*, not of Polyakov), and *C.r. vosnessenskii* (= *E. latastei* J. A. Allen), N. G. Buxton (Allen 1903a) says, ". . . In the houses they are active during the entire year, and I think young are born in every month, but on the tundra they are inactive during the winter; . . ." The attraction which houses and food stores have for *C. rutilus* is well known (See Stejneger 1884, p. 89; Porsild, 1945).

missing) in juvenal peltage taken by him at Lapie River is dated June 11, 1944. This skin shows no evidence of new growing hair, and the mouse had probably only recently left the nest for the first time. Since it appears

TABLE I
List of embryos, placental scars, and young in order of
dates of capture

Reindeer Station.....	June 3, 1933	5 nestlings	Porsild (1945)	—
Lapie River.....	June 11, 1944	6 embryos	N.M.C. 17660	2nd year
Lapie River.....	June 15, 1944	6 placental scars	N.M.C. 17677	2nd year
Lapie River.....	June 21, 1944	7 embryos	N.M.C. 17713	2nd year
Lapie River.....	June 22, 1944	5 embryos	N.M.C. 17717	2nd year
30 mi. S. of Aklavik.....	June 23, 1949	7 implantations	U.B.C. 3347	2nd year
30 mi. S. of Aklavik.....	June 24, 1949	7 very young embryos	U.B.C. 3348	2nd year
Port Radium.....	June 26, 1945	6 small embryos	R.O.M.Z. 16468	2nd year
Port Radium.....	June 26, 1945	7 embryos	R.O.M.Z. 16471	2nd year
Port Radium.....	June 29, 1945	4 very young embryos	R.O.M.Z. 16467	2nd year
Seward Peninsula.....	July 1, 1948	7 embryos 20x11 mm.	(Quay, 1951)	—
Swede Lake, central Alaska	July 9, 1950	6 embryos	R. L. Strecker (<i>in litt.</i>)	—
Rose River.....	July 10, 1944	5 embryos	N.M.C. 17804	2nd year
Reindeer Station.....	July 10, 1947	5 embryos	U.B.C. 2297	1st year
Perry River.....	July 13, 1949	5 young 1 month old	Hanson (1955)	—
Central Alaska.....	July 15, 1950	5 born	Morrison <i>et al.</i> (1954)	—
Central Alaska.....	July 17, 1950	7 born	Morrison (<i>in litt.</i>)	—
Central Alaska.....	July 19, 1950	6 born	Morrison <i>et al.</i> (1954)	—
Central Alaska.....	July 21, 1950	6 born	Morrison (<i>in litt.</i>)	—
Central Alaska.....	July 22, 1950	7 born	Morrison <i>et al.</i> (1954)	—
Perry River.....	July 22, 1949	6 placental scars	Morrison (<i>in litt.</i>)	—
Haines Road Junction.....	July 22, 1943	7 embryos	Hanson (1955)	—
Central Alaska.....	July 23, 1950	8 born	N.M.C. 17331	1st year
Nisutlin River.....	July 29, 1944	5 embryos	Morrison <i>et al.</i> (1954)	—
Sheldon Lake.....	Aug. 5, 1944	4 embryos	N.M.C. 17947	2nd year
Reindeer Station.....	Aug. 6, 1948	4 implantations ¹	N.M.C. 17967	2nd year
Carcross.....	Aug. 16, 1949	6 embryos	U.B.C. 3339	2nd year
Sheldon Lake.....	Aug. 16, 1944	9 very small embryos	N.M.C. 20235	2nd year
Clinton-Colden Lake.....	Aug. 30, 1948	4 placental scars	N.M.C. 18029	2nd year
			R.O.M.Z. 23303	1st year

Most of the data were obtained from the skin labels of the specimens examined. The age (i.e., first or second year) was determined from the skulls accompanying the skins. Since the records are from different years and widely different localities, no breeding pattern can be expected, especially as some of the collectors were not active throughout the season.

¹Two resorptions.

from Morrison *et al.* (1954, p. 382) that *C. rutilus* leaves the nest about the eighteenth day, this specimen was probably born about May 20. The last date on which a pregnant female has been recorded is August 16. Corresponding closely to this, the latest date of capture for any skin seen with enlarged mammae is September 8. Another is dated September 5. Both were taken at St. Michael, Alaska, in 1899. However, there has been little spring, autumn, or winter trapping, and since the length of the breeding season may vary considerably in different years according to the stage of the population cycle, it is probable that as records become more plentiful the period within which young are born may be found to extend from early May to early September. Referring to the Anaktuvuk Pass region of Alaska, Rausch (1951) says, "Breeding apparently begins in May and has stopped by early September."

Although evidence of simultaneous pregnancy and lactation in *C. rutilus* under natural conditions has not been recorded in the literature or on the labels of the specimens examined, all but two of the skins of the pregnant females listed in Table I show clear evidence of well-developed mammae. Where the embryos are recorded as very young, this must be considered evidence of lactation. It may be supposed, therefore, that, as in *C. glareolus* (Brambell and Rowlands, 1936, pp. 79, 96), pregnancy frequently occurs at post partum oestrous. Svihla (1929) also reported the birth of two litters of *C.g. gapperi*, only 18 days apart, to a single captive female. He gives the gestation period, based on records from six captive females, as 17 to 19 days. Allowing for possible delayed implantation caused by lactation, it would be theoretically possible, therefore, for a single female to have four, possibly five, litters in the year. Actually, the frequency of litters, like the length of the breeding season, may vary with the stage of the population cycle or even with the geographical and climatic conditions. In 1944, Rand (1945) considered that several litters per female were born in the Canol Road region, but at Tuktoyaktuk and Aklavik in 1951 and 1952, the bimodal distribution of condylobasal length in the first year mice (Figures 2, 4) is suggestive of only two litters, or at least of an interruption in the breeding period prior to the final pregnancy of the season¹. In the following discussion the larger first year mice (condylobasal length above 21.5 mm. in the Tuktoyaktuk series, and above 22.3 mm. in the Aklavik) are therefore referred to as 'early' litter young, and the small mice as 'late' litter young. The asymmetrical distribution of condylobasal lengths of the supposed early litters (Figure 4) must be explained by a rather sudden halt in breeding after a more gradual start, although this appears to be contrary to observations on related species.

POSSIBLE EFFECT OF WEATHER ON MOVEMENTS OF YOUNG MICE

No mice with a condylobasal length under 21.5 mm. ('late' litter mice) were taken at Tuktoyaktuk in September, 1951, and only one prior to October 6 in 1952. One small mouse was caught on October 6, and between then and October 17 they were comparatively numerous; then they again

¹Coventry (1937, pp. 492-493) explains a drop in the percentage of pregnant *C. gapperi* in Ontario during June and early July by a pause in breeding after one or two litters, and possible evidence of a similar pause in late summer is given by Morris (1955, p. 28). On the other hand, Brambell and Rowlands (1936, p. 77), with more material, found that the percentage of pregnant females of *C. glareolus* rose in a smooth curve to a maximum in June and then declined steadily.

vanished (Figure 2). The significance of the difference between the proportion of small mice (i.e., under 21.5 mm.) caught during the 12-day period, October 6-17, and the small proportion caught in 1951 before and after that period was tested in a 2 x 3 table.¹ The resulting chi-square value was 15, $n=2$, $P < .01$. Even when the specimens of small mice obtained after October 17 were not considered (since the lack of small mice after this date might be due to a different cause), the adjusted chi-square was 6.0 and P still less than .02.² This sudden appearance of small mice and their subsequent apparent disappearance might have been caused by population movements, but it appears more likely that it was associated with changes in the weather, although these changes were not so abrupt and do not fit the trapping results so exactly that they afford positive proof. There was a high wind with drifting snow during the few days in September, 1951, when that year's collection was made,³ and it was again cold and rather windy during the first four days of October, 1952, the mean daily minimum temperature⁴ then being $+13.5^{\circ}\text{F.}$, the mean maximum, $+25^{\circ}\text{F.}$, and the maximum daily wind force varying from 2 to 7. On the 5th, 6th, and 7th of October the minimum daily temperatures were $+25^{\circ}\text{F.}$, $+33^{\circ}\text{F.}$, and $+29^{\circ}\text{F.}$, the maximum, 40°F. each day, and the maximum recorded wind forces, 4, 3, 1, respectively. Thus, October 7, the day on which two small, 'late' litter, mice were caught for the first time, was the first really calm, mild day. The mean of the daily minimum temperature recorded between October 5 and 17 was $+24.3^{\circ}\text{F.}$ ($+17^{\circ}$ to $+33^{\circ}$) F. , and of the daily maximum temperature, $+32.1^{\circ}\text{F.}$ ($+27^{\circ}$ to $+40^{\circ}$) F. There does not appear to have been any significant change in the weather on the 18th when no small mice and only one large mouse were caught⁵, but this low catch may have been due to chance or to fewer traps having been set or visited. On the next two days there was snow with winds of force 2 to 5. Although the recorded snowfall amounted to only 1.5 inches, a considerably greater quantity accumulated amongst the long grass and low scrub, so that for the first time mice could easily forage below the surface. More snow fell on October 23, and the next day the temperature dropped to $+10^{\circ}\text{F.}$; on the 26th, it went below zero for the first time. The poor catch on October 12 and 13 may or may not be correlated with the 1.5 inches of snow which fell on the afternoon of the 11th and during the following night. Weather conditions do not account for the scattered catch of small mice obtained on certain days outside the period October 6 to 17 (Figure 2). At Aklavik, the weather was cold but calm during five days of the 1951 September trapping period. In November of the following year the weather was fairly normal for the season, but the mice, though no bigger, were doubtless considerably older, and thus presumably able to withstand better the colder weather. Perhaps more important, the garbage dump at which they were caught was

¹Seven specimens not shown in Figure 2 have been included in the calculations. Three were taken sometime between October 20 and 29, and four between October 18 and November 4.

²This test is somewhat artificial in that the dates were selected by inspection of the data being tested. However, dates giving almost as high a chi-square value might have been selected from the meteorological data. A still higher chi-square would result from the inclusion of the 1951 specimens.

³These were obtained from Eskimos, who presumably trapped them in or near their houses. To what extent the mice were actually living in the houses, and therefore presumably not affected by the weather, is not known.

⁴The records for October, 1952, taken by Miss D. L. Robinson, were furnished through the courtesy of the Meteorological Division, Department of Transport.

⁵A second mouse was caught on the 18th, but its skull was too badly broken for the condylobasal length to be determined. It is obviously small and might have been a 'late' litter specimen. Two other specimens obtained from Eskimos were taken between the extreme dates of October 18 and November 5.

well sheltered by scrub, and thus in a very different situation from the exposed Tuktoyaktuk barrens. Our failure to catch the smaller Red-backed Mice during bad weather at Tuktoyaktuk may be related to the poor temperature regulation of nestlings and the low body temperature of mice of this species under 28 days (See Morrison *et al.*, 1954).

GROWTH AND SEXUAL MATURITY

Figure 2 shows clearly that the average condylobasal length of the first year Red-backed Mice from 'early' litters (condylobasal length over 21.5 mm.) caught at Tuktoyaktuk in 1952 did not increase appreciably during October. Also, these October specimens are no larger than those taken in September of the preceding year, and the similarity between the condylobasal lengths of September, 1951, and November, 1952, Aklavik specimens is even more striking. Moreover, when considered in relation to the length of adult skulls (Figure 4), there is equally good agreement between the condylobasal length of first year skulls from the two places. Thus, the condylobasal length of 1951 and 1952 'early' litter mice from Tuktoyaktuk¹ is 94 per cent of adult size (i.e., second year mice), and that of those from Aklavik, 93 per cent.² The condylobasal lengths of both Tuktoyaktuk and Aklavik 'late' litter mice are 89 per cent of adult size. From the above it may be inferred with some certainty that there is little or no growth as measured by condylobasal length³ in *C. rutilus* during the winter months. Further evidence of a winter halt in growth is afforded by the small average size of second year June mice. Thus, the 19 southwestern June specimens with a mean condylobasal length of $23.70 \pm .13$ mm. are significantly smaller ($t=2.7$, $P < .02$) than the 27 southwestern adults (mean condylobasal length = $24.09 \pm .08$) taken in July, August, and September, while the smallness of the two June Aklavik specimens (Figure 2) is very marked. However, since all but one of these June southwestern specimens are from Lapie River, a genetic basis for their small size is possible, but unlikely in view of the many specimens from neighbouring parts of the Canol Road included with the later summer series, and in view of the fact that the mean condylobasal length of the five June Lapie River specimens with 'well rooted' molars (and therefore presumably physiologically older than the remainder) is 24.16 mm., or slightly greater than the mean for second year southwestern specimens taken after July 1. Also, as Figure 20 shows, most of the difference between the June and later specimens is in diastema length, a region of the skull believed on other grounds (p. 45) to be late in attaining its full dimension. Somewhat contradictory evidence

¹The two adult-sized first year females, one from Tuktoyaktuk and one from Aklavik (See Figure 2), have been omitted from this calculation.

²Adult size of the Aklavik mice was determined from all available post June Aklavik and Caribou Hills second year specimens.

³Throughout this paper condylobasal length has been taken as an indication of the total size of the mouse. This is not entirely satisfactory, particularly as growth in condylobasal length is greatest in the forward part of the skull, and as there are evidently changes in the differential growth rates during the winter. Variability of tail lengths, however, makes total length measurements unconvincing, and head and body measurements, obtained by deducting tail length from total length, also show discrepancies. Sumner (1927) has pointed out the precautions necessary for obtaining accurate body measurements, and Howell (1924, p. 985) estimates that the possible error on the average label may be up to 10 per cent. Our Tuktoyaktuk and Aklavik mice were often frozen when found, and it was sometimes inconvenient to thaw them completely before skinning, especially as the belly hair was found to slip within a very short period of thawing. The comparison of measurements, particularly measurements so likely to vary with different techniques of two or more observers, is never satisfactory, and once the animal has been skinned and destroyed, there is no possibility of checking measurements which are later found to have an apparent error.

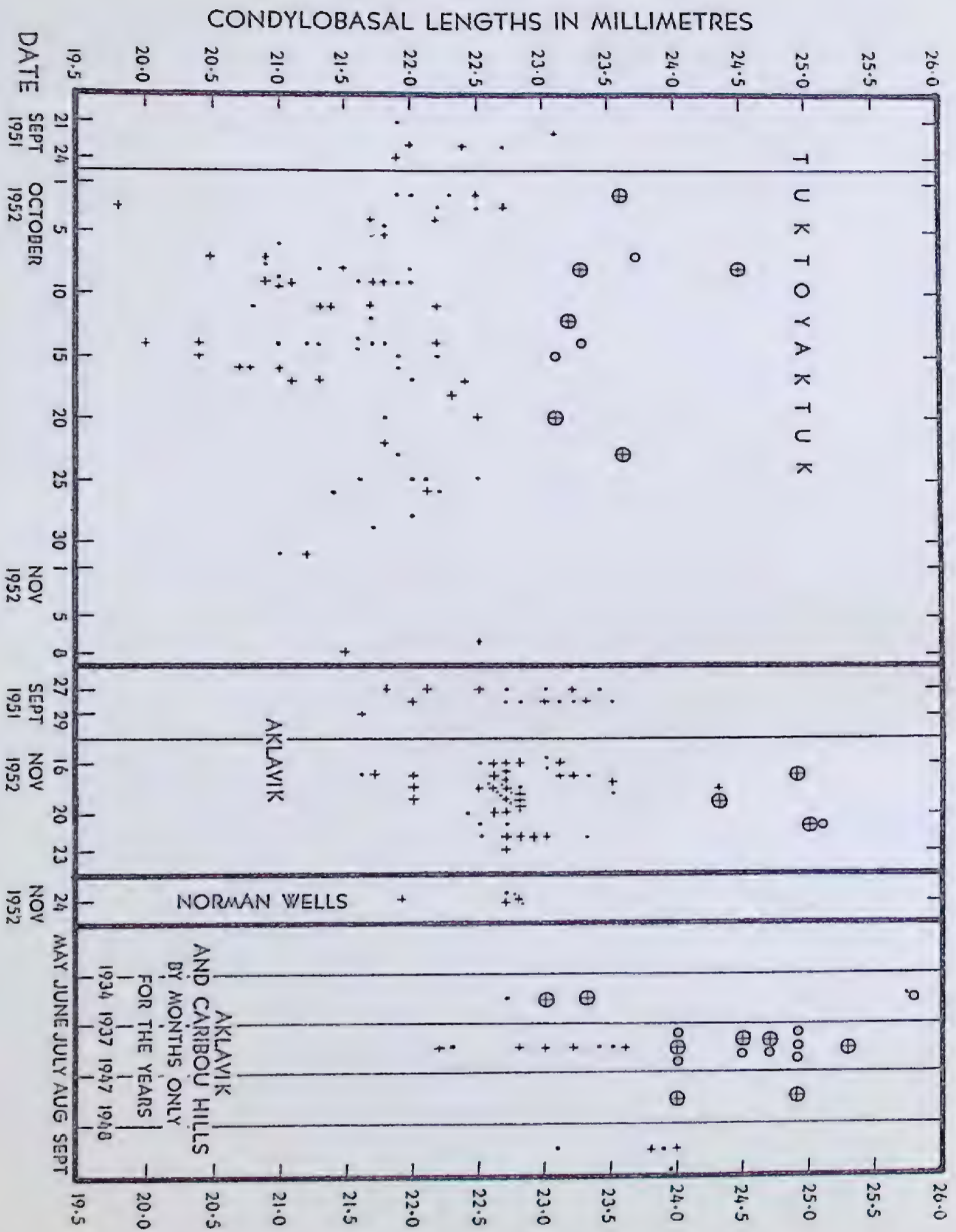


Figure 2. Condylobasal lengths of Tuktoyaktuk, Aklavik, and Norman Wells specimens plotted against date of capture.

• = 1st yr. ♂ ⊙ = 2nd yr. ♂
+ = 1st yr. ♀ ⊕ = 2nd yr. ♀

As in Table I, the year is assumed to commence on June 1, so the single May specimen is regarded as a first year mouse although born during the preceding

is given by the east Siberian April-series, the condylobasal length of which is not significantly smaller than that of the second year east Siberian-Behring Island series taken later in the year (Table V, Figure 6). A possible explanation is that, as with an earlier collection from Nijni Kolymsk (Allen, 1914), many of the winter and early spring specimens were trapped in or around houses, where the heat and abundant food contributed to early spring growth (See also p. 5 footnote). Half of this April series was made up of mice with molar teeth just beginning to root.

Interruption of growth during winter is apparently not confined to *C. rutilus* or to the arctic and subarctic. The similarity of September to March weights of *C. glareolus* (Brambell and Rowlands, 1936, Figure 1;

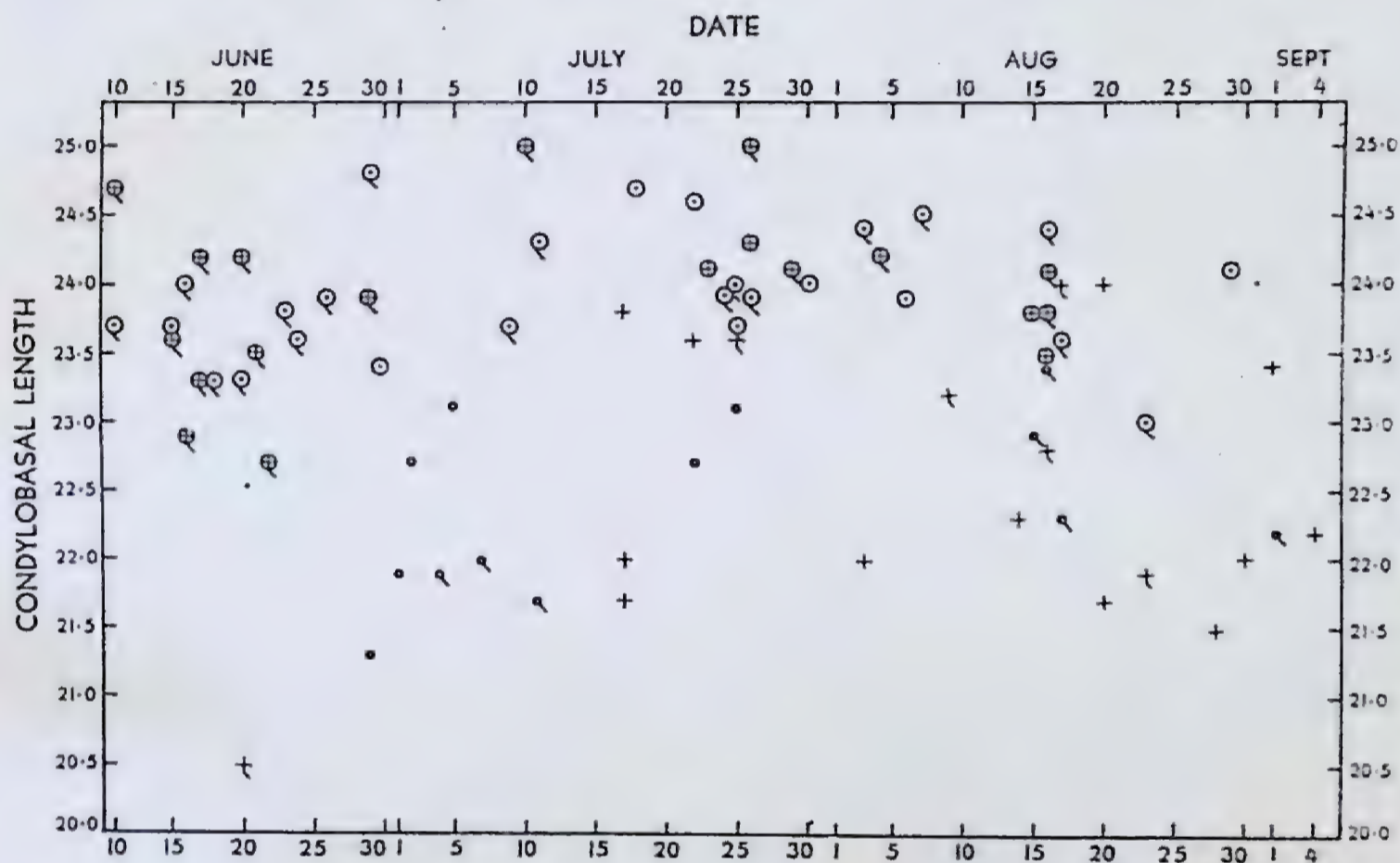


Figure 3. Condylobasal lengths of southwest region summer specimens plotted against date of capture.

• = 1st yr. ♂ ⊙ = 2nd yr. ♂
 + = 1st yr. ♀ ⊕ = 2nd yr. ♀

Symbols with tails represent 1944 Canol Road specimens.

Rowlands, 1936, Figure 2) and of *Microtus agrestis* (Baker and Ranson, 1933, Figures 2, 4) indicates that there can be but little growth in these species even in Britain. In both species, increase in weight in spring occurs first in the males. Some of this increase may be due to fat accumulation, but it seems barely possible that the absence of weight increase during the winter can have been caused by loss of fat and flesh while the mouse continued to grow in length.

calendar year. A few specimens have been omitted from this figure because the exact date of their capture was unknown or because the skulls were too broken for satisfactory measurement of condylobasal length. June mice are from Aklavik; July and August mice, from the Caribou Hills, which includes the Reindeer Station specimens.

Winter growth may be inhibited by a dual mechanism. The apparent lack of growth in the supposed 'late' litter mice, as evidenced by the similarity in condylobasal length (taken as a percentage of the length of adult skulls) between mid-October Tuktoyaktuk (89 per cent) and mid-November Aklavik (also 89 per cent) and Norman Wells specimens (Figures 2, 4), suggests that winter growth may be prevented directly by a decrease in food supply or by some other seasonal factor. Experimental support for this is given by Ferry (1913), who found that rats which had been starved from the time of weaning would, on being returned to a full diet, grow at a rate normal to their size rather than to their age. On the other hand, Figures 2 and 3 show that the condylobasal length of a surprisingly large number of July and August mice already equals that of the wintering first year mice in the 1951 and 1952 collections. The similarity is particularly striking between the November Aklavik and the July Aklavik and Reindeer Station series. This could be chance. For instance, in 1951 and 1952, when only two specimens out of the whole series of first year mice were of adult size, the breeding season at Tuktoyaktuk, Aklavik, and Norman Wells may have begun late. However, it is tentatively suggested that in some individuals, particularly males, growth may be interrupted at 94 per cent of adult size even if this size is reached as early as July. It is also suggested that these retarded animals do not develop sexually until the following spring, when growth recommences. Were it not that Stotsenburg (1909, 1913)¹ had found that gonadectomy did not retard growth in the albino rat, it might be thought that the interruption in growth was directly due to lack of sexual development. However, even if the two phenomena are the result of a common cause, it would still follow that sexual development begins at about 94 per cent of adult size, or perhaps slightly lower, the variation about this mean probably being similar to the variation in full-grown adults (i.e. second year mice taken after June). It would also follow that first year mice which have attained adult or near-adult size will have reached sexual maturity. In the October to January first-year series of *C.r. jochelsoni*, which may not be a random sample of the population, there is a slight and not necessarily significant gap in the distribution about a condylobasal length of 22.9 mm. It is suggested that the six specimens above this reached sexual maturity the preceding summer, but that the 11 below it did not. The mean condylobasal length of the 11 immature specimens is 22.47 mm., or 94 per cent of adult size.

In Britain, male *C. glareolus* born early in the summer become sexually mature (Rowlands, 1936, p. 120), and females breed during their first summer (Brambell and Rowlands, 1936, p. 76). Coventry (1937, pp. 492-493) also suspected that *C.g. gapperi* in Ontario breed during their first season. In the present series of *C. rutilus*, out of 16 skulls of females labelled as pregnant or parous (Table I), only three had unrooted teeth. One of these (with 7 embryos), N.M.C. 19331, taken on July 22, 1943, had a condylobasal length of 23.6 mm., and distinctly open sutures. It could hardly have been a second year animal, but the very early date and the large number of embryos give rise to a suspicion that the skull might have been confused with that of a second year individual during cleaning. Another, U.B.C. 2297, with five embryos, taken at the Reindeer Station on

¹His observations were confined to weights in the males, and to weights and total length in the females. Growth in the rostral region of the skull, which contributes most to the increase in condylobasal length, may still be controlled by sex hormones.

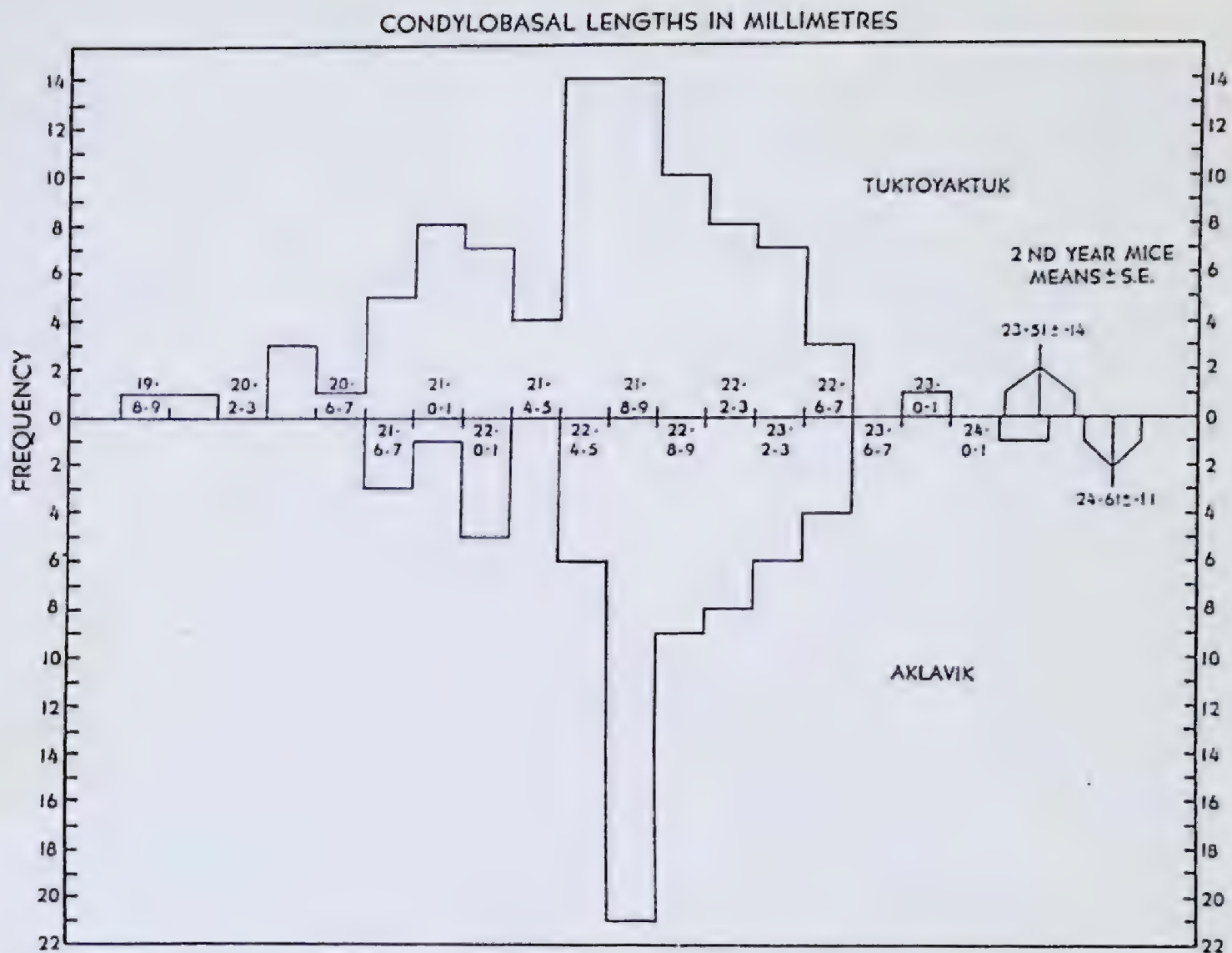


Figure 4. Comparison of condylobasal lengths of Tuktoyaktuk and Aklavik 'early' and 'late' litter first year and second year mice.

The upper histogram, showing the 1951 and 1952 Tuktoyaktuk catch of the first year mice, and the lower histogram, showing the Aklavik catch of first year mice for the same years, have been moved to the left and right respectively, so as to bring together the gaps in the distribution. This has also caused the means of the full grown adults (second year mice collected after June) to lie within two (actually 1.7, $P > .05$) standard errors of difference, thus strengthening the supposition that the gaps in the two series result from a common cause.

Second year mice from the Caribou Hills and Reindeer Station have been included in the mean of Aklavik second year series.

July 10, 1947, still has large alveolar capsules, but might possibly be a second year animal. If not, it must surely have been born early in May. The third female, R.O.M.Z. 23303, which was taken on August 30, 1948, at Clinton-Colden Lake, and which had four placental scars and a condylobasal length of 23.7 mm., appears to afford the best evidence of breeding by a first summer animal. In addition, out of 21 skins with evidence of enlarged mammae but no comments on the label, six are believed to be first year mice, although one, taken on July 15, 1947, at Caribou Hills, and one on July 25, 1944, at Nisutlin River, are in the doubtful class. The other first year specimens were taken at St. Michael, Alaska, on September 5 and 8, 1899; Atlin, September 1, 1934; and Sheldon Lake, August 17, 1944. Thus, out of a total of 37 pregnant or lactating *C. rutilus*, about 20 per cent are probably in their first year. Large, and therefore sexually mature, first year males appear less common than females (Figures 2 and 3).

LITTER SIZE

Table I gives the available information on litter size and embryo counts of *C. rutilus*. The mean, $5.93 \pm .23$, is .46 larger than that given by Coventry (1937) for 49 embryo counts of *C. gapperi* in Ontario. Although this difference is not significant ($t=1.9$, $P<.1>.05$), both figures are distinctly larger than the mean, 4.11, given by Brambell and Rowlands (1936) for embryo counts in 70 late pregnancies¹ of *C. glareolus* in Britain, and it is possible that litter size increases with the severity of the climate and the consequently shortened breeding season.

SEX RATIO

Our Northern Red-backed Mouse collections of 1951 and 1952 (See p. 2) may be considered a random sex sample in so far as it is possible to obtain one by trapping. The total was 103 males and 102 females, which clearly does not differ materially from 50 per cent male. Neither do any of the collections considered separately for the three places and two years vary significantly from that figure. The biggest variation was at Aklavik in 1952, when we took 23 males and 37 females (adjusted $\chi^2=2.8$). However, of the 38 specimens taken at Tuktoyaktuk in 1952 onward from October 18 (the date on which small mice disappeared), 26 were male. This is significantly more than 50 per cent (adjusted $\chi^2=4.4$), and if the limiting date were taken as October 19, the date on which it first became possible for the mice to make runways below the snow, 25 out of 36² specimens would be males, and the adjusted chi-square value would be 4.7. This high proportion of males might have been caused by a movement of the wider ranging sex into a partially trapped-out area (See Worth, 1951). It is believed, however, that the traps had been moved sufficiently far and often to prevent this, and it is thought more likely that the females, like the younger subadults, tended to keep under the snow. The Aklavik and Norman Wells catches, having been made at garbage dumps, would not be affected.

INDIVIDUAL VARIATION IN SIZE

On the whole, the coefficients of variation for the second year mice given in Tables V to X, and XII, appear lower than those for most adult mammals (See Simpson and Roe, 1939, p. 123). This indicates that there is only slight variability at full growth, and provides evidence that, although growth may not have ceased by June 1, or even July 1, of the second year (See p. 11 and discussion of the different skull measurements) it must be very slow during the second summer. The low value of the coefficients of variation for the first year Tuktoyaktuk and Aklavik mice may be attributed partly to uniformity in age, and partly to cessation of growth at a certain size (See p. 12). The coefficient of variation for the combined first and second year mice from the southwest region is naturally rather

¹If the six birth counts are raised by .4 young per litter, and the two later litter counts by .7 young per litter to equate them with embryo counts (Ranson, 1941; Manning, 1954), the mean counts for *C. rutilus* would be 6.06 instead of 5.93. This gives a difference of .59 from Coventry's embryo counts for *C. gapperi*, which, using the same standard deviation, is significant ($t=2.4$, P about .02). However, apart from the necessary assumptions, the justification for the adjustment in this particular case may be doubted, as the mean of the litter counts in Table I is already slightly greater than the mean of the embryo counts.

²Five males labelled October 18 to November 5 are still included, as these were extreme dates.

higher, but considering that it represents the total variability in the active population, it may still be considered unusually low, perhaps even for the Microtinae. This small variability may be caused, at least in part, by young *C. rutilus* leaving the nest and starting to forage for themselves at an unusually late age, and Svihla (1929, p. 487) found that in the absence of a second litter, captive *C. gapperi* suckled for at least three weeks.

From comparisons with captives of known age, Morrison *et al.* (1954, p. 382) considered that the youngest specimens of *C. rutilus* they obtained during the summer trapping were about 18 days old. Judging by the unworn enamel on m3, and almost unworn enamel on M3, the youngest in the present series was 18032 from Sheldon Lake. However, this skull is too broken to measure. One other, 17709, from Lapie River, the smallest measurable skull from the southwest region, still retains the enamel over the last prism of M3. The condylobasal length of this skull is 20.5 mm., which is 85 per cent of adult size (i.e. second year post June mice) or 82 per cent of the size of the largest mouse taken from the area. The latter figure may be compared with that for the smallest *M.m. yosemite* measured by Howell (1924), which was only 79 per cent of the size (condylobasilar length) of his largest specimen. The smallest *C.r. washburni* skull, C.N.M.H. 72943, with condylobasal length 21.8 mm., is 86 per cent of second year size. The smallest Tuktoyaktuk specimen, N.M.C. 20824, has a condylobasal length of 19.8 mm. This is only 84 per cent of adult size, but since its molars are fully developed, it is probably older than N.M.C. 17709, and owes its small size to retarded growth.

VARIATION OF SIZE WITH SEX

Since the size of *C. rutilus* varies geographically, and since the proportion of males to females in the collections from different areas also varies, the whole series cannot be lumped together to obtain the size difference between the sexes without first weighting the measurements according to their district of origin. This would be an inconvenient and probably inexact process. Separate tests of adult and subadult groups from different areas have therefore been made, and the result is given in Table II. In the Tuktoyaktuk and Aklavik series, which were random samples of the first year mice, the males are the larger, but the difference is significant only in the former (P about .02), where it probably results from the heterogeneity of the sample and the varying percentage of the sexes in its different parts. Thus there are more females than males amongst the small specimens thought to result from a second litter, and significantly more males than females amongst those caught after October 17, when it is believed that both females and small individuals tended to keep below the snow and be less readily trapped (See *Sex Ratios*).

Possible sex differences in measurements, other than condylobasal length or in the relative measurements have not been tested mathematically, but the frequency diagrams from which r and b_{yx} were calculated indicate no obvious sexual variation when different symbols were used for plotting males and females.

The general conclusion is, therefore, that if there is a difference in size between the sexes, it is too small to be shown by the samples available, and therefore too small to warrant treating the sexes separately. The

larger size of the females, noted by Hanson (1952) in his small series of *C.r. washburni*, can be ascribed to chance. It may also be doubted if there is as yet sufficient reliable evidence to support his implication that female microtine rodents generally tend to be larger than males. For instance, the reverse is indicated by measurements of *Microtus pennsylvanicus pennsylvanicus* (Goin, 1943; Snyder, 1954) and of *M. montanus yosemitem* (Howell, 1924). There may be a greater range of variability in the females, but the larger coefficients of variation for females in Table II are, in part, due to a few adult-sized females amongst the first year specimens. These are perhaps chance variations, but they may indicate a tendency for more females than males to mature in the first year. In at least two species of *Microtus* there appears to be more variability in male skulls (Howell, 1924, p. 998; Goin, 1943, pp. 215-217¹).

TABLE II
Comparison of condylobasal lengths of males and females

	No.	Mean	S.D.	C.V.	Mean ♂ - ♀	t
First year mice						
Oct.-Nov., 1952. Tuktoyaktuk. ♂	46	21.75 ± .07	.42 ± .05	1.9 ± .2	+.31	2.4
♀	36	21.44 ± .13	.73 ± .09	3.4 ± .4		
Sept., 1951, Nov., 1952. Aklavik. ♂	26	22.80 ± .08	.38 ± .05	1.7 ± .3	+.12	1.0
♀ ¹	37	22.68 ± .09	.50 ± .06	2.2 ± .3		
June-Sept. Southwest area. ♂	12	22.08 ± .23	.79 ± .17	3.6 ± .8	-.62	1.7
♀	15	22.70 ± .25	.96 ± .18	4.2 ± .8		
Second year mice						
June-Sept. Southwest area. ♂	24	23.93 ± .10	.47 ± .07	2.0 ± .3	.00	—
♀	19	23.93 ± .15	.62 ± .10	2.6 ± .5		

¹The single adult-sized female (see Figure 2) has been retained since it is almost certainly a first year specimen. If the comparison had been between subadult (i.e., sexually immature) males and females, it would have been omitted, and the standard deviation and coefficient of variation of the two sexes would have been more similar. There are also a few large and probably sexually mature females in the first year series from the southwest area (see Figure 3).

MOULTS

It seems doubtful if the second subadult moult, which has been observed in some of the more southern microtinae² and is probably irregular in *Dicrostonyx groenlandicus* (MS. notes on captives), occurs as such in *C. rutilus*. Its place is taken by an autumn moult which affects the first and second year mice equally. Occasionally, even the juvenal moult may

¹Snyder (1954, p. 208) points out that his figures for coefficient of variation in *M. p. pennsylvanicus* are considerably lower than those of Goin. This is not, as Snyder suggests, because of a more restricted age sample, but because of evident errors in the calculation of the standard deviations, standard errors, and coefficients of variation given by Goin.

²*Microtus californicus* (Hatfield, 1935). *Microtus ochrogaster* (Jameson, 1947).

coincide with the autumn moult, in which case there is probably no further moult until spring.

In the juvenal Northern Red-backed Mouse, the fur, particularly on the back of the neck and head, is usually finer, softer, and thinner than on the adult or post-juvenal. However, it may not always be possible to distinguish juvenals and post-juvenals with certainty. The youngest juvenals examined had probably only left the nest a few days before being trapped. In these the fur of the back was little, if any, duller, than in the

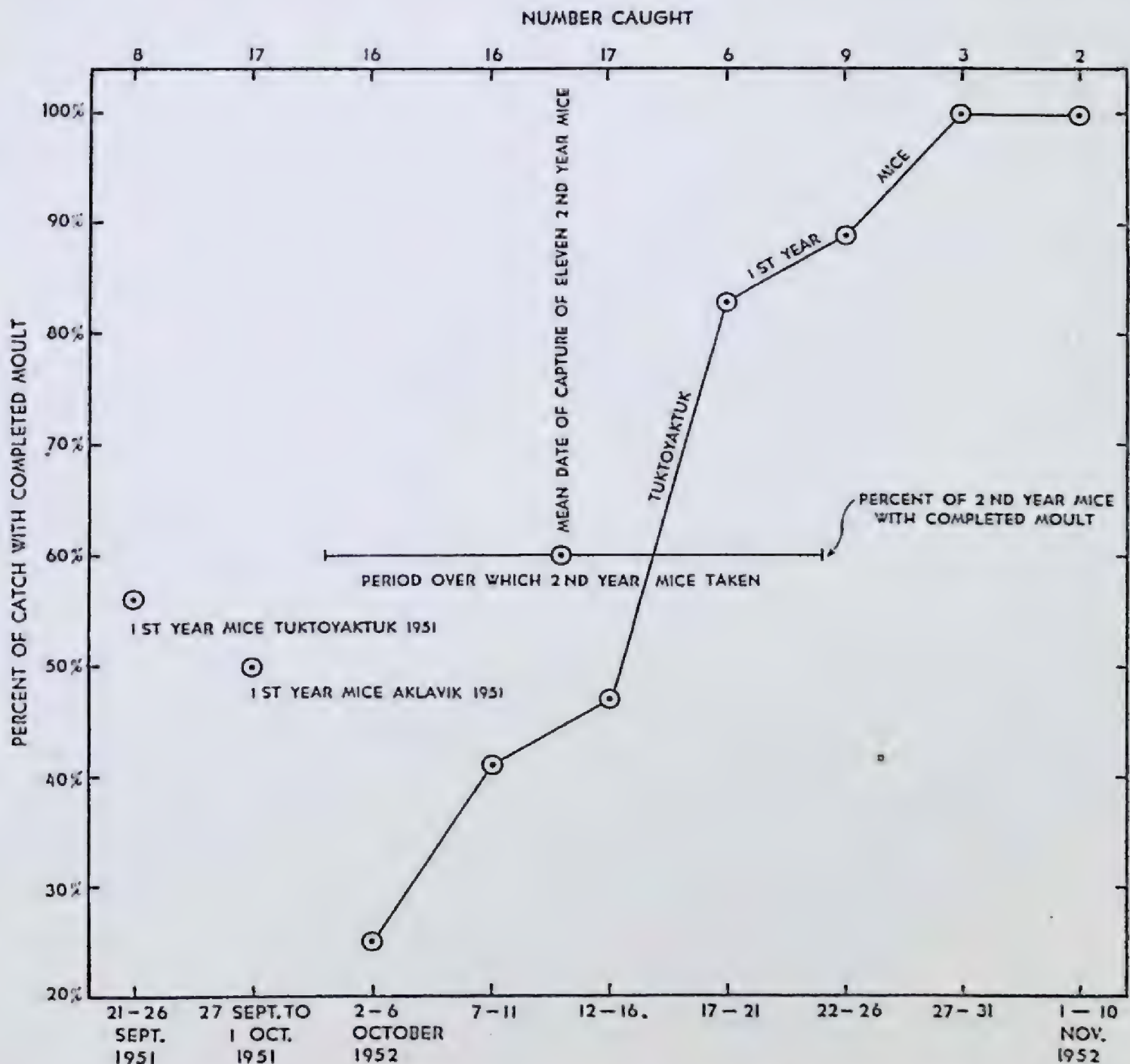


Figure 5. The autumn moult at Tuktoyaktuk and Aklavik in 1951, 1952.

The ascending line shows the percentage of first year 1952 Tuktoyaktuk specimens which have completed or almost completed the autumn moult; the horizontal line indicates the period over which second year Tuktoyaktuk mice were taken in 1952; and the circle shows their mean date of capture plotted against the percentage with completed moult. The percentages of 1951 Tuktoyaktuk and Aklavik first year mice are also shown by circles plotted against the appropriate dates. An individual was considered to have completed its moult when there was no more growing hair on the main body area and the skin appeared prime. Naturally there were a few specimens which might have been put into different classes by another worker, and occasionally there was some doubt if a specimen had completed or had not started its moult.

adult. Apparently the dull peltage, sometimes said to be characteristic of the subadult, appears only with wear and becomes really marked only during the post-juvenal moult. Most of the Tuktoyaktuk specimens believed to be moulting from juvenal to winter peltage are not appreciably duller than those moulting from post-juvenal to winter peltage. The grey under-fur on the ventral surface of juvenal specimens tends to show through more than in most adults (except nursing females). This also is probably the result of wear. With the completion of the post-juvenal moult, the young mouse develops a coat at least as bright as the second year summer adult—sometimes even brighter and softer.

Amongst the collection of southwestern specimens in the National Museum are six subadults, which are still in juvenal peltage. Their mean head and body length is 77.8 mm. (73 mm.—80 mm.), and condylobasal length (four specimens), 21.0 mm. (20.3 mm.—21.9 mm.). The mean head and body length of nine moulting specimens from that area was 91 mm. (81 mm.—99 mm.), and the condylobasal length of five of these with intact skulls, 21.8 mm. (21.5 mm.—22.3 mm.)¹. The smallest condylobasal length of any subadult with complete, or nearly complete, juvenal moult was 21.9 mm. Other specimens are only slightly larger. If they have all been assigned to their correct category, there is an overlap in condylobasal length between specimens that have not started to moult and those in which the moult has been completed. It appears probable that there is therefore a considerable individual variation in the age at which the post-juvenal moult takes place.

Second year mice usually moult between late September and late October, but two of the ten August southwestern second year males (N.M.C. 18028, Aug. 16; N.M.C. 18037, Aug. 17) are commencing to moult. At Tuktoyaktuk in 1952, three male and three female second year mice were taken with prime or near prime skins and winter peltage between October 8 and 23 (mean, October 15), but a male taken October 7, and three females taken October 2, 8, 12 (mean, October 7) respectively, had growing hair. Another second year male killed between October 20 and 29 also had growing hair. Figure 5 shows that half the subadult population of *C. rutilus* at Tuktoyaktuk in 1952 had completed their autumn moult by about mid-October, and no truly moulting individuals were caught after October 26. However, a few specimens taken at Norman Wells as late as November 24 still had a little growing hair on the head and face, which appeared to be the last place to complete the autumn moult. Also, there can be no doubt that the body hair, like that of several other arctic mammals, continued to grow longer and thicker well into November, although the main body peltage is probably changed and the skin becomes prime relatively quickly.

There appeared to be no appreciable difference between the moulting dates of males and females in the Tuktoyaktuk and Aklavik areas, nor was there any significant difference between the moulting dates of those with a condylobasal length over 21.5 mm. ('early' litters) and those with a smaller measurement ('late' litters), although it might have been expected that the date on which an individual had completed its juvenal moult would affect

¹A sixth skull, N.M.C. 17981, condylobasal length, 23.2 mm., probably does not belong to the skin with the corresponding number and head and body length of 87 mm.

the date of its autumn moult if these came close together. Both Tuktoyaktuk and Aklavik 1951 first year specimens appear to show an earlier moult (Figure 5), but the difference is more apparent than real, since a large proportion of that year's specimens from both places still have growing head hair and are only just referable to the 'moult completed' group.

The following May skins have been examined: Norman Wells, 1, May 8; Reindeer Station, 1, May 13; Port Epworth, 3, May 25-26; Coppermine, 2, May 9. All are in winter peltage. One Coppermine specimen shows small patches of growing hair on the head, sides, and throat, the other on the rump. The rest of both skins is prime. The other five skins show no evidence of growing hair or the dark skin associated with growing hair. Twenty-three June (first taken June 11) second year mice are obviously in summer peltage, although averaging slightly paler and yellower than July and August specimens (See p. 21). One of these, taken on June 23, has short growing hair on the sides and belly, and another, taken on June 29, has patches on the rump. The remaining June specimens show no evidence of growing hair. It is probable, therefore, that there is no complete spring moult, and that the summer peltage is derived by wear and shedding of the pale buff hair. There may also be some growth of scattered dark hairs, and, in some individuals, a more complete coat change in irregular patches. If it is correct that second year mice retain much of this worn winter fur, it might be possible to separate them from first year animals by microscopic examination of individual hairs. Certainly most second year mice have a coarser-feeling, less regular coat than first year animals which have completed their post-juvénal moult.

INDIVIDUAL AND GEOGRAPHICAL VARIATION IN PELTAGE

The enormous colour range which may occur in a single population of some species of *Clethrionomys* has been illustrated by Bangs (1897, colour plate). In the collections of *C. rutilus* examined, the range of individual variation is much less, particularly in summer peltage. Indeed, when allowance is made for variations caused by season and wear, the peltage within most populations is reasonably constant. Of the series examined, the greatest variability of dorsal colouring occurs amongst the September, October, and November Tuktoyaktuk skins and the November Aklavik skins. The former series includes a few specimens still apparently in summer peltage, but most of them are either growing new hair or are in nearly perfect winter peltage. The Aklavik November specimens are in almost complete winter peltage. No true summer skins are available from Tuktoyaktuk, and only four from the vicinity of Aklavik. This is too few to show the range of colour variation in summer peltage. However, 34 summer skins from the Caribou Hills and Reindeer Station, which is only 40 miles from Aklavik, show no more variation than those from the southwest region. It is suspected, therefore, that although the variation of the Tuktoyaktuk and Aklavik mice in summer peltage may be greater than that of the other populations studied, probably including the Caribou Hills-Reindeer Station, it is distinctly less than it is in winter peltage. Conversely, it may be that the other populations would also show a greater variety of colour in winter.

Colour phases. Only three of the 386 skins of *C. rutilus* examined belong to the dark, or grey, colour phase. One, a second year male (U.B.C. 3570) in summer peltage, was taken in September, 1951, at Mt. McKinley Park, Alaska. Another is a first year female taken at Aklavik on September 28, 1951 (N.M.C. 20738), apparently in partial winter peltage. Both these specimens have a dorsal stripe with a general colour between Sepia and Fuscous.¹ The third specimen, N.M.C. 9489, taken at Aklavik on October 29, 1927, is in more definite winter peltage. It is distinctly paler, the dorsal stripe is between Sepia and Saccardo's Umber, and the sides are more buffy. All three specimens are separated from the Bister (grade 6 of Table III) Tuktoyaktuk specimens by the sharp boundary between their dark dorsal stripe and pale sides rather than by the actual

TABLE III
Winter skins graded according to dorsal colour

Grade	Tuktoyaktuk	Aklavik	Norman Wells	Tuktoyaktuk = Kittigazuit	East Siberia
6	6	—	—	2	—
5	19	3	—	—	—
4	20	10	1	3	—
3	17	12	2	2	1
2	3	24	6	6	1
1	—	15	5	13	4
Mean grade	4.12 ± .13	2.21 ± .15	1.93 ± .24	2.12 ± .30	1.93 ± .24
S.D.	1.04 ± .10	1.14 ± .01	0.88 ± .17	1.50 ± .21	0.88 ± .17

The reddest (Cinnamon or Orange-Cinnamon) skins are grade 1, the greyest (Bister), grade 6. The standard deviations and errors should be considered as a general guide only.

colour of the dorsum. However, it is thought that in full summer peltage specimens from the greyer end of the winter Tuktoyaktuk and Aklavik series would be much redder, whereas specimens belonging to the true dark colour phase are equally grey, and perhaps darker in summer than in winter. Another specimen, taken 9 miles south of Aklavik on June 13, 1947 (U.B.C. 2885), shown in Plate I, has a Snuff Brown dorsum and no pronounced back stripe. This may be either an aberrant individual or a representative of a distinct colour phase. The light-phased male which Preble (1908) took at Fort Good Hope may be similar.° He says, "The dorsal stripe is yellowish brown, only slightly different from the sides anteriorly, but becoming darker toward the rump."

Dorsum: winter skins. Table III shows the frequency with which six different grades of dorsal redness-greyness occur in series of skins in reasonably complete winter peltage from different populations. The reddest

¹Capitalized colours are from Ridgway (1912).

(Cinnamon or Orange-Cinnamon) specimens are graded as 1, the greyest (Bister), as 6 (See colour plate, frontispiece). There are, of course, no breaks between the grades. Evidently about 80 per cent of the Tuktoyaktuk specimens may be separated by the greyness of the dorsum from a like percentage of Aklavik specimens. In addition, equivalent grades of Tuktoyaktuk specimens average darker on the dorsum, and are darker and greyer on the sides. This, however, may be due in part to incomplete growth of the winter peltage, since most of the Tuktoyaktuk series were taken in October, and most of the Aklavik in November. On the other hand, it is believed that the dorsum becomes greyer as the winter advances, so that had the Tuktoyaktuk series been in full winter peltage, a greater proportion would have been separable from the Aklavik specimens. As would be expected from the evidence provided from the skulls, the Norman Wells series clearly agrees best with that from Aklavik. At first it seemed strange that, with the exception of two grade 6 skins, the 25 flat skins taken in the winter of 1927-28 and labelled Tuktoyaktuk also matched the Aklavik series rather than the 1951-52 Tuktoyaktuk series. However, Dr. A. E. Porsild, who obtained these flat skins from a trader, tells me that a few may have come from Tuktoyaktuk, but most were taken near Kittigazuit, which is 18 miles southwest in the direction of the Reindeer Station. At Kittigazuit the willow scrub is much higher than at Tuktoyaktuk, and the boundary between the two races may lie at the edge of this higher scrub. Unfortunately there are no skulls with these flat skins, and their identification must be considered tentative. The 12 skins and 16 skulls from 8 miles south of Tuktoyaktuk do not differ from the specimens taken in or near the settlement.

Three Port Epworth and one Coppermine specimen, taken between March 26 and May 26, closely match grade 1 Aklavik specimens, although their red dorsal stripes averaged slightly darker and brighter. Two other Coppermine specimens, taken May 6, are closer to some of the Tuktoyaktuk specimens of grade 2. They have a bright red dorsal stripe interspersed with some bright blackish hairs. Only six skins of *C.r. jochelsoni* have been graded, but others in the United States National Museum were examined. All are clearly closer to the Aklavik series than to the Tuktoyaktuk in redness, as opposed to greyness, of the dorsum as well as in general paleness. In addition, some specimens are a distinctly brighter red than any Canadian winter skins seen.

Face and sides in summer. In all populations there is some variation in the greyness as opposed to yellowness (Buckthorn Brown) of the face, and a grey-faced individual usually has grey on the sides: in fact, shows a general reduction of yellow-tipped hair. However, it is thought that the sides may be more influenced by wear, which, by reducing the longer, yellow-tipped hair, increases the greyness. After excluding the obviously worn juvenal skins, the 40 remaining July and August study skins from the southwestern region were divided into equal-sized grey- and yellow-faced groups. It was then found that only five of the 23 June skins from that area match the grey group. This difference, which is just significant ($\chi^2 = 3.8$), could have been caused by a genetic difference in the Lapie River population, from which 20 of the skins were taken, but it seems more likely that the June skins are yellower because of the persistence of some of the long, yellow-tipped winter hairs of the face and sides. The limited number

of June skins seen from other areas also supports this hypothesis. After obviously worn juvenals have been eliminated, there does not seem to be a significant difference between the proportion of July and August second year mice with yellow faces and the proportion of July and August first year mice which are similarly coloured. Not enough specimens are available to tell if there is a difference between June skins of first and second year mice. It may be concluded that for inter-population comparisons, July and August specimens may be grouped together, as may first and second year mice, provided obviously worn juvenals are excluded; but June skins must be compared separately. Some growth of yellowish winter hair may occur on the sides of September specimens before the general moult begins, but the new hair is very likely late growing on the face (See *Moult*) so that most September specimens not in advanced moult can probably be compared for facial colour with July and August specimens. Certainly there is no apparent difference between the July and August southwestern series and the six specimens from that region taken in early September. Later in the month there may be some change.

A single July Aklavik (Campbell Lake) specimen matches the southwestern yellow-faced group, 16 late September Aklavik skins average yellower than the six southwestern early September skins, and two June (23 and 24) Aklavik mice are distinctly yellower than the comparable southwestern skins. From this it is tentatively concluded that Aklavik summer skins are, on the average, rather yellower-faced than comparable southwestern specimens. There is also a tendency to yellowness in the five June Port Radium specimens and in the July Yellowknife skin. These yellowish skins may certainly be described as 'bright', and one may suspect that they would be matched by the "three typically bright-coloured specimens" which Banfield (1951) obtained between June 25 and July 11 in the taiga habitat at Fort Reliance. If so, there would seem to be an unusually yellow population extending eastward from Aklavik just within the tree line to the Keewatin District, where it may spread over the southeastern part of the barrens. The August Yellowknife specimen matches the yellow southwestern group. The 23 July and August Caribou Hills-Reindeer Station specimens closely match the comparable series from the southwest region and may be divided about equally into yellow- and grey-faced groups.

The ten Clinton-Colden¹ and six Aylmer Lake August specimens in second year or post-juvenal peltage have very dark sides and faces, with some almost black hair above the nostrils. Also, the circular, yellowish moustache patch² of other *C. rutilus* skins is reduced or absent, and the white of the throat usually extends farther up about the nostrils. These two characters are also present in the seven specimens from Perry River, the three from Artillery Lake, and the one from Kasba Lake, although they average slightly yellower on the face and sides. Contrary to Hanson (1952), however, the Perry River skins are no more buffy than comparable specimens from the southwestern region. Using the three facial characters in conjunction, the Perry River-Clinton-Colden Lake-Aylmer Lake-Kasba Lake-Artillery Lake series stands out clearly from the southwestern region-

¹Seven of these specimens were from the ten collected by Banfield (1951), who also remarked on their darkness and correctly suggested that they might represent a then undescribed race.

²Generally Cinnamon Buff in summer; paler and less conspicuous in winter.

Aklavik-Caribou Hills series, and with two or three possible exceptions amongst the large southwestern series, all individuals can be correctly separated. The facial characters of nine July flat skins from the Thelon Sanctuary are not easily compared, but seven appear to match the Perry River series fairly closely, while two are nearer the southwest series. The faces of two Baker Lake and five Smoke Lake August skins clearly match the greyer section of the southwestern series, while seven August skins from Victory Lake are yellower and closely match the summer (including September) Aklavik skins.

Most of the 28 Tuktoyaktuk specimens, which are still chiefly in summer peltage, fall into the grey-faced group and in addition tend to have a darker face, sometimes with reduced moustache patch. In this they resemble the Perry River-Aylmer Lake series, from which four skins are apparently inseparable.

Dorsum in summer skins. As pointed out above, there is probably less individual variation in the dorsal colouring in summer than in winter. There may also be less difference between populations. In general, yellow-faced specimens tend to have a paler dorsal stripe. Of the geographical groups, the Aklavik, Port Radium, Yellowknife, and Victory Lake series average palest, but this may in part be due to the season (June) in which many of them were taken, and in any case the samples are too meagre to give more than an indication of the population average. The Tuktoyaktuk, Aylmer Lake, and Clinton-Colden Lake series are the darkest. The others, including the Perry River specimens, are more intermediate and show considerable overlap. The dorsal stripe appears to be narrowest, particularly about the shoulders, in the southwestern series, and widest in the Victory Lake series. However, this difference may be caused largely by the way the skins are made up.

Worn juvenal skins. Judging by a comparison of four late August Aylmer Lake and two September Artillery Lake specimens with nine June, July, and August southwestern skins, juvenals from the former area in an advanced state of peltage wear average distinctly darker than those from the southwest. One July Reindeer Station juvenal and one August Victory Lake juvenal closely match comparable southwestern specimens. A July specimen from the Thelon Sanctuary matches the Aylmer Lake-Artillery Lake series. One Victory Lake and one Aylmer Lake specimen, both just starting to grow new hair, are shown in the coloured plate. Most juvenal Tuktoyaktuk specimens show less wear, perhaps because the advancing season has hurried the moult, but four which are nearly comparable are intermediate in colour between the southwestern and the Aylmer Lake-Artillery Lake series. Worn summer juvenals from Tuktoyaktuk would probably be darker.

Underparts. Hanson (1952), in his original description of *C.r. washburni*, drew attention to the whiteness of the underparts of his Perry River specimens. Table IV shows that this character holds for other populations of that race, although it is too early to say that mice with buff-tipped ventral guard hairs may not occur, or even predominate, in local groups of otherwise typical *C.r. washburni*. The great majority of *C.r. dawsoni* from the southwest have buff-tipped ventral guard hairs, but in a few local populations, mice with white underparts may be moderately common.

TABLE IV
The proportion of skins lacking buff-tipped ventral guard hair.
A few were too dirty or worn to be included.

	No. of specimens	No. with white underparts	Per cent with white underparts	5% confidence limit for percentages
<i>C.r. dawsoni</i>				
Canol Road.....	59	2	3	0-12
Norman Wells.....	15	9	60	32-85
Other places in southwest area.....	28	4 ¹	14	3-34
Aklavik and neighbourhood.....	93	10	11	5-20
Caribou Hills.....	24	6	25	9-48
Tuktoyaktuk [= Kittigazuit].....	26	9	35	17-57
Port Radium.....	5	2	—	—
Yellowknife.....	2	1	—	—
Victory Lake.....	8 ²	8	53	26-79
Smoke Lake (5) ² , Baker Lake (2).....	7	0		
Alaska. Chitina Glacier.....	12	3	35	16-58
Mt. McKinley Park.....	3	1		
St. Michael.....	6	2		
Teller.....	1	1		
Point Barrow.....	1	1		
<i>New subspecies</i> (See p. 50)				
Tuktoyaktuk, 1951-1952.....	94	40	43	32-54
<i>C.r. washburni</i>				
Perry R. (9) ³ , Aylmer L. (10).....	51	51	100	92-100
Clinton-Colden L. (10), Kasba L. (1).....				
Artillery L. (5), Thelon Sanctuary (10).....				
Coronation Gulf (6) ⁴				
<i>C.r. jochelsoni</i>				
East Siberia.....	6	3	—	—

The proportion of skins lacking buff-tipped ventral guard hair. A few were too dirty or worn to be included.

The 5% confidence limits were taken from Figure 4 in Clopper and Pearson (1934).

¹Kathleen River 1, Carcross 1, Alaska Highway mile 213 1, Nahanni River 1.

²The Smoke Lake and Victory Lake specimens are similar in size and were taken from a very small area (Manning, 1948). It is even possible that they are two sets of siblings.

³Hanson (1952). Only 7 seen by me.

⁴One borderline skin with a very small amount of pale buff.

This is illustrated by the Norman Wells series, in which a high proportion of mice have white underparts and the buff-tipped hairs of the remainder are unusually pale compared with Canol Road specimens. Toward the northern (and perhaps eastern and western) extremities of the range of *C.r. dawsoni*, there may be a more general increase in the number of individuals with white underparts. Nevertheless, there is probably a step in the cline at the boundary of *C.r. washburni*. The 1927-28 series of flat skins from Tuktoyaktuk (=Kittigazuit, see p. 21) probably contains a few specimens actually taken in the Tuktoyaktuk area and therefore referable to the new race described on page 50.

As a matter of convenience, in the above discussion and in Table IV the colour of the underparts has been treated as dichromatic, but actually, in those areas from which a large number of buff specimens is available, a series can be laid out grading from white through very light buff to a comparatively deep buff, and even amongst the white-bellied specimens there are degrees of whiteness or brightness, the Perry River series averaging the brightest, followed by other *C.r. washburni* populations. However, wear in many of the summer skins, particularly of lactating females, would make grading difficult, and an accurate comparison of summer and winter skins impossible. Even with the single division there are a few specimens in Table IV which another worker might classify differently.

It appears that even in *C.r. dawsoni* whiteness of the underparts is often associated with a greater amount of white on the face and a tendency for the dorsal surface of the feet to be white.

SKULL MEASUREMENTS

In a short-lived cyclic animal, taxonomic comparisons of absolute measurements of samples containing growing animals will be misleading unless they are taken at the same time of year and at the same stage of the population cycle, since these variables will greatly affect the age structure of the population. Even if the above conditions are apparently fulfilled in some collections, local weather or other unknown factors may have caused variations in the samples themselves, as, for instance, an abnormally low proportion of very young animals (See pp. 7-8). Or again, the collector, faced with more specimens than he requires, may have failed to preserve the whole catch. Amongst the collections considered here, those from the southwest region (*C.r. dawsoni*) are at least roughly comparable for season with those of *C.r. washburni*, and the supposed lack of growth in some measurements in autumn and winter may make the Tuktoyaktuk and Aklavik series reasonably comparable for these measurements. However, in most cases, an attempt has been made to avoid the variables mentioned above by confining the comparison of absolute measurements to second year specimens and using regression coefficients to reduce skull measurements other than condylobasal length to a standard condylobasal length. These precautions unfortunately do not eliminate entirely the effect of the variables. It has been shown above¹ that the mean condylobasal length of a series of June second year mice is significantly less than that of specimens taken later in the summer. This is apparently due principally to

¹p. 9. The possibility is there mentioned that the small size of the available June specimens could be due to genetic difference in the Lapie River population, from which most were obtained.

growth in the forward part of the skull, the diastema length particularly being affected (Figure 20). Growth after June 1 in nasal length and in zygomatic and mastoid breadth is also appreciable, but probably not in depth of skull through the bulla or in maxillary tooth row length. No tests have been made, but it is thought that, with a few possible exceptions, skull growth has virtually ceased in most dimensions after July 1, although widening and strengthening of the zygoma may continue into old age. Variation in the condylobasal length of June specimens may be expected from year to year, depending on the time at which breeding ceased the preceding autumn, and, as pointed out on page 11, and shown in Table V and Figure 6, the mean of *C.r. jochelsoni* April series is not significantly smaller than that of the series (i.e., second year specimens) taken later in the year. If sufficient second year specimens are available, it might therefore be best to exclude those taken in June from absolute comparisons of most skull measurements. In the present paper this has been done only for condylobasal length. Since the mean condylobasal length, 24.16 mm., of five June Lapie River skulls with 'well rooted' molars agrees well with the mean of the later southwestern specimens, it appears probable that these five are full grown and could be considered with the later summer specimens. Indeed, if enough skulls with well-rooted teeth were available, absolute comparisons confined to these, irrespective of season, would probably be ideal. Advantage of the apparent full growth of specimens with well-rooted teeth has been taken only in the case of *C.r. jochelsoni*. There were insufficient second year specimens of that race taken after July 1, and undated and early spring skulls with well-rooted molars were therefore included for the comparison of condylobasal length. If this has caused a bias, it is probably toward greater condylobasal length in the *C.r. jochelsoni* series. For comparison of measurements other than condylobasal length, all *C.r. jochelsoni* specimens with molars 'rooted' or 'just rooted' have been included to balance the inclusion of June specimens in some of the other series. Again, in comparison with the series used for the other races, the mean size of the skull measurements of *C.r. jochelsoni* may have been slightly exaggerated. It was expected that, by reducing the skull measurement of the different samples to a common condylobasal length, the relative measurements so obtained would be comparable, irrespective of the variation in the age structure of the populations from which the samples were obtained. It was soon apparent, however, that for most measurements considered, there was a change in relative growth rate in the winter months, apparently caused by a continued growth in skull breadth and depth during the period when increase in condylobasal length was small. Even relative measurements of, say, mid-summer, autumn, and late winter, first year specimens are therefore not entirely comparable, and allowance for this must be made in interpreting the tables and figures. A considerable difference may be expected in the skull proportions of an autumn specimen which had reached sexual maturity during its first summer, and one with similar condylobasal length which matured the following spring when it was captured. However, it may be expected that had the first lived until spring, it would also have grown in skull width during the winter, and both would therefore have the same skull proportions. This needs further investigation.

Huxley (1932) showed that in many instances heterogonic growth follows an exponential curve. However, when k is near unity, this curve

does not normally depart materially from a straight line over a small range of measurements, and the rectilinear regressions are adequate both to show differences in the relative growth increments, and for reducing measurements of one part or plane to a standard of another. The arithmetic treatment of growth has some disadvantages, but for the present purpose it has the advantage that the mean measurements of additional collections may be quickly plotted on the graphs, and affinities of the populations from which the collections were drawn thus indicated in a simple and obvious fashion. The line of equal relative growth passing through the origin of the graph and based on the ratio of the means of the Tuktoyaktuk first year series may be obtained by joining the mean of that series to the arrow in the upper right-hand corner of the regression line graphs.

There is a fundamental difference between the regressions of the first and second year specimens, in that variations in the measurements of the former are mainly due to variations in the growth stages, while variations in the latter result principally from individual variation in adult size.

Skull measurements were all taken with the same pair of vernier calipers measuring a tenth of a millimetre. The measurements were checked once, and a third reading taken if the difference between the first two exceeded .1 mm. Maxillary tooth row and diastema measurements were taken on the left side of the skull. Calculations were done with a slide rule, and a slight inaccuracy in the third figures of the standard errors can therefore be expected. The standard deviations and their derivatives in the Tables were calculated with the formula

$\sqrt{\frac{\mathcal{E}(fd^2)}{N}}$, but for the Figures, they were multiplied by $\sqrt{\frac{N}{N-1}}$. The stan-

dard error of estimate and its derivatives, i.e. the standard error of regression and the standard error of the adjusted mean, were calculated by the formula

$S_{yx} \sqrt{1-r^2} \sqrt{\frac{N}{N-2}}$ in both Tables and Figures. In order to use the same

value of $\mathcal{E}(d^2_x)$ for calculating the regressions of the different measurements of the same series, damaged skulls have been eliminated in most calculations. This has resulted in a few anomalies, such as the reference on page 15 to the smallest *C.r. washburni* skull having a condylobasal length of 21.8 mm., whereas the smallest measurement given in Table V is 22.3 mm.

Condylobasal length and skull depth were the only two measurements taken on a few specimens measured at the American Museum of Natural History and at the United States National Museum. The specimens from the University of British Columbia were not borrowed until most of the calculations had been completed. They have been used in second year Aklavik-Caribou Hills series for all measurements, and in the combined first and second year Aklavik-Caribou Hills series for maxillary tooth row.

Condylobasal length (Table V, Figure 6). For reasons given on p. 9, condylobasal length has been used as an index of total size. It has also been used as the independent variate in calculating the regression and standard error of estimate of the other skull measurements.

The similarity between the condylobasal lengths of second year *C.r. jochelsoni* and the Tuktoyaktuk population is as striking as their difference from *C.r. dawsoni* and *C.r. washburni* (Figure 6). There is also a

TABLE V

Estimated parameters in mm. for condylobasal lengths

Race	Origin	Period	No.	Range	Mean	S.D.	C.V.
Second year mice							
New subspecies.....	Tuktoyaktuk.....	Oct.	10	23.1-24.5	23.51 ± .126	.40 ± .095	1.8 ± .40
<i>C.r. dawsoni</i>	Aklavik-Caribou Hills.....	July-Nov.	16	24.0-25.3	24.61 ± .105	.42 ± .075	1.7 ± .31
<i>C.r. dawsoni</i>	Southwest region.....	July-Aug.	27	23.0-25.0	24.09 ± .086	.44 ± .061	1.8 ± .26
<i>C.r. washburni</i>	Perry R.-Aylmer L.....	July-Aug.	5	24.9-26.0	25.32 ± .199	.44 ± .141	1.8 ± .58
<i>C.r. jochelsoni</i>	E. Siberia (12)-Behring I. (1).	Chiefly winter	13	22.7-24.6	23.58 ± .162	.59 ± .115	2.5 ± .49
First year mice							
New subspecies.....	Tuktoyaktuk.....	Sept.-Nov.	82	19.8-23.1	21.67 ± .067	.61 ± .048	2.8 ± .22
<i>C.r. dawsoni</i>	Aklavik.....	Sept.-Nov.	65	21.6-24.3	22.79 ± .063	.50 ± .045	2.2 ± .20
<i>C.r. dawsoni</i>	Southwest region.....	June-Nov.	29	21.3-24.0	22.71 ± .153	.82 ± .108	3.6 ± .48
<i>C.r. washburni</i>	Perry River-Aylmer L.....	Aug.-Sept.	13	22.3-24.2	23.14 ± .155	.56 ± .110	2.4 ± .48
<i>C.r. jochelsoni</i>	E. Siberia.....	Oct.-Jan.	17	22.1-23.7	22.78 ± .114	.47 ± .081	2.1 ± .36
<i>C.r. jochelsoni</i>	E. Siberia.....	April	20	22.1-24.5	23.43 ± .112	.50 ± .096	2.1 ± .34

Standard deviation calculated by formula $\sqrt{\epsilon(fd^2)/N}$. June specimens have been omitted from the Aklavik and southwestern second year series in order to obtain the size at full growth (see section on Growth and Sexual Maturity). The November Norman Wells specimens are included with the first year southwest region series. Half the east Siberian April series have molar teeth which are just beginning to root; all were born the preceding summer, but are considered first year mice until May 1.

significant difference ($t = 3.1$, $P < .01$) between the small series of second year *C.r. washburni* and the next largest-skulled population, that of *C.r. dawsoni* from the Aklavik-Caribou Hills region, as well as between the latter and the south-western population of the same race ($t = 3.7$, $P < .01$). On the basis of condylobasal length about 91 per cent of the Tuktoyaktuk second year series are separable from the same percentage of the Aklavik-Caribou Hills series, whereas only 72 per cent of the latter can be separated from the southwestern series.

The first year series of nearctic mice follow the same pattern as the second year series, but it must be remembered that the summer Perry River-Aylmer Lake series and the southwestern region series are not strictly comparable with the autumn Aklavik and Tuktoyaktuk series. The higher proportion of early litter mice in the Aklavik series may have

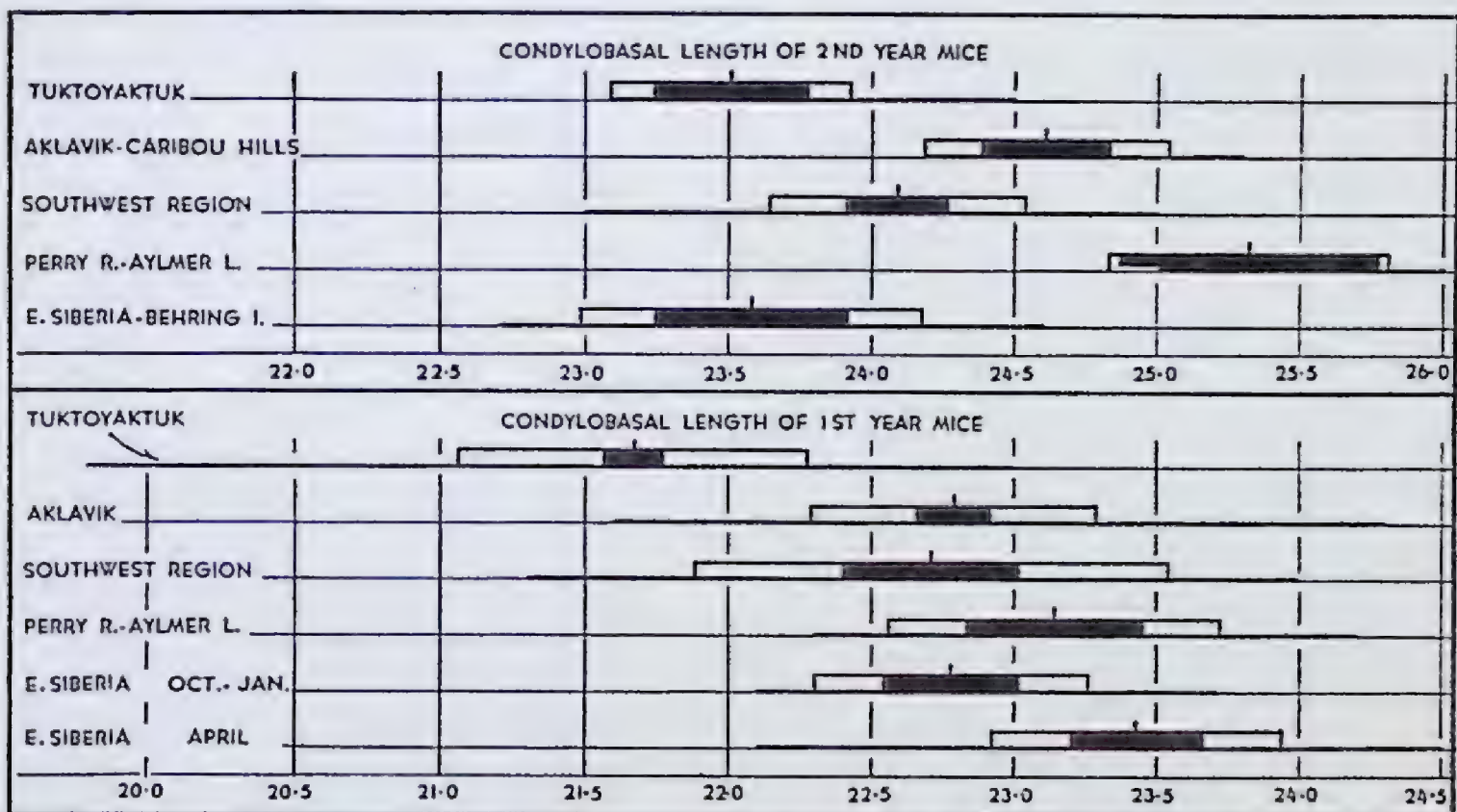


Figure 6. Condylobasal lengths plotted from figures derived from Table V.

The heavy base lines represent observed ranges; the white triangles, the best estimates, $\sqrt{\frac{\sum (fd^2)}{N-1}}$, of the standard deviations of the populations; the black rectangles, twice the standard errors of the mean. Rect.

slightly exaggerated the difference in mean size between it and the Tuktoyaktuk series. The percentage of joint non-overlap is only 84, a distinct drop from that of the second year samples, but this is principally owing to the larger standard deviation naturally associated with subadult populations. April specimens of *C.r. jochelsoni* are a better match for the second year series than for the first year October-January series, indicating that condylobasal growth had apparently begun again. There may also have been some winter growth in the January specimens. (See *Growth and Sexual Maturity*.)

Skull depth (Table VI, Figures 7, 15). This measurement was taken so as to give the greatest depth of the skull from the posterior portion of the parietal bone to the ventral side of the tympanic bulla. The jaws of

TABLE VI

Estimated parameters in mm. for skull depth Y and its correlation with and regression on condylobasal length X

Race	Origin	Period	No.	Range	Mean	S.D.	C.V.	r	z	b _{yx}	S _{yx}	\bar{y} when $\bar{x} = 24.5$
Second year mice												
New subspecies	Tuktoyaktuk	Oct.	10	8.1-8.7	8.38 ± .055	.17 ± .038	2.1 ± .46	—	—	.17 assumed	—	8.58
<i>C.r. dawsoni</i>	Aklavik-Caribou Hills	June-Nov.	22	8.5-9.4	8.94 ± .053	.25 ± .037	2.8 ± .42	.60	.69 ± .23	.23 ± .068	.21	8.94 ± .045
<i>C.r. dawsoni</i>	Southwest region	June-Aug.	42	8.6-9.5	9.05 ± .033	.21 ± .024	2.4 ± .26	.39	.41 ± .16	.15 ± .057	.20	9.17 ± .045
<i>C.r. washburni</i>	Perry R.-Aylmer L.	July-Aug.	4	8.7-9.8	9.42 ± .225	.45 ± .159	4.8 ± 1.69	—	—	.17 assumed	—	9.28
<i>C.r. jochelsoni</i>	E. Siberia (13)-Behring I. (3)	Chiefly winter	16	8.1-9.0	8.54 ± .055	.22 ± .039	2.6 ± .45	.31	.32 ± .28	.12 ± .098	.22	8.65 ± .107
Second and first year mice												
New subspecies	Tuktoyaktuk	Sept.-Nov.	82	7.8-8.7	8.24 ± .019	.17 ± .014	2.1 ± .17	.22	.22 ± .12	.06 ± .031	.17	8.29 ± .032
<i>C.r. dawsoni</i>	Aklavik	Sept.-Nov.	65	8.3-9.2	8.75 ± .024	.19 ± .017	2.2 ± .20	.49	.54 ± .13	.19 ± .042	.17	8.69 ± .025
<i>C.r. dawsoni</i>	Southwest region	June-Nov.	29	8.3-9.3	8.80 ± .051	.27 ± .036	3.1 ± .41	.23	.23 ± .20	.08 ± .062	.27	8.78 ± .054
<i>C.r. washburni</i>	Perry R.-Aylmer L.	Aug.-Sept.	13	8.3-9.3	8.88 ± .075	.27 ± .053	3.0 ± .60	.59	.68 ± .32	.28 ± .118	.24	8.71 ± .100
Second + first year mice												
New subspecies	Tuktoyaktuk	Sept.-Nov.	10+82	7.8-8.7	8.25 ± .019	.18 ± .014	2.2 ± .16	.28	.29 ± .11	.06 ± .023	.17	8.29 ± .023
<i>C.r. dawsoni</i>	Aklavik	Sept.-Nov.	8+64	8.3-9.2	8.75 ± .022	.19 ± .016	2.1 ± .18	.37	.39 ± .12	.09 ± .029	.18	8.70 ± .025
<i>C.r. dawsoni</i>	Southwest region	June-Nov.	42+29	8.3-9.5	8.95 ± .033	.27 ± .023	3.1 ± .26	.51	.56 ± .13	.15 ± .032	.24	8.81 ± .041
<i>C.r. jochelsoni</i>	E. Siberia (57)-Behring I.(3)	Chiefly winter	15+45	8.1-9.0	8.47 ± .026	.20 ± .019	2.4 ± .22	.41	.44 ± .14	.13 ± .038	.19	8.39 ± .034

Standard deviation calculated by the formula $\sqrt{\epsilon (fd^2)/N}$. Standard error of estimate: $S_{yx} = \sigma_y \sqrt{1-r^2} \sqrt{N/N-2}$.

The assumed regression coefficient used for adjusting the new subspecies and *C.r. washburni* second year series is an unweighted mean of the three calculated values for the second year specimens.

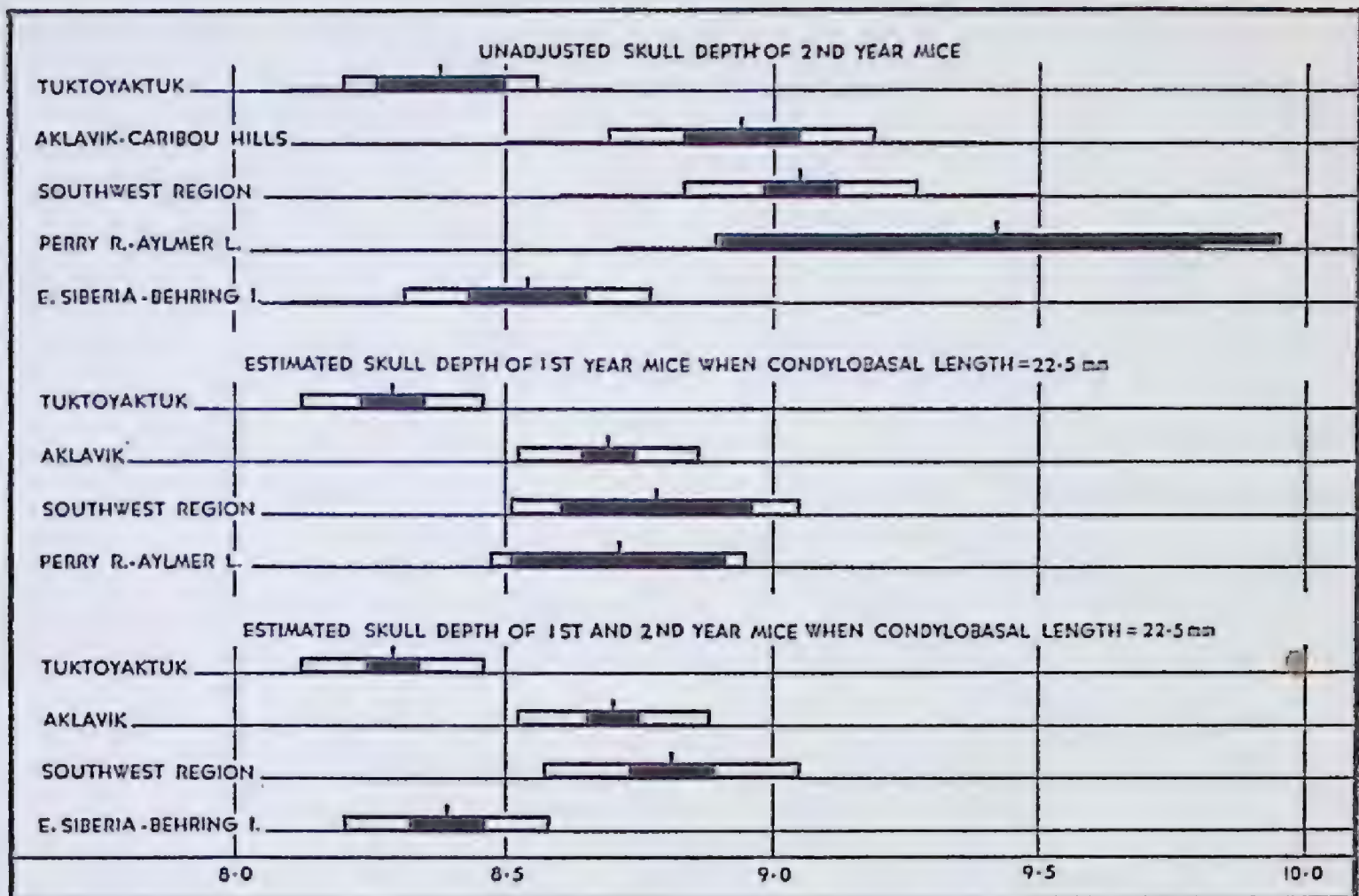


Figure 7. Skull depths plotted from figures derived from Table VI.

In the diagram with unadjusted means, the heavy base line represents the observed range; the white rectangles, the best estimates, $\sqrt{\frac{\sum (fd^2)}{N-1}}$, of the standard deviations of the populations; the black rectangles, twice the standard errors of the mean. In the diagrams of adjusted means, the white rectangles represent the standard errors of estimate: $S_{yx} = \sigma_y \sqrt{1-r^2} \sqrt{\frac{N}{N-2}}$; the black rectangles, the standard errors of the adjusted means: $S_{yx} \sqrt{\frac{1}{N} + \frac{(X-22.5)^2}{\sum d_x^2}}$

the calipers, which were 2 mm. thick, were held at right angles to the long axis of the skull, and the skull allowed to find its own angle in them. This was nearly, but seldom quite, perpendicular to the basal plane of the skull.

The greatest interest in skull depth centres about the flat-skulled Tuktoyaktuk series. Since it is this, the smallest race, which has the relatively flattest skull, identification of individuals is easiest by absolute measurements, and since differences in skull depth between age groups are comparatively slight, absolute measurements may be used with fair confidence for the comparison of series of approximately similar age.

Between the Tuktoyaktuk and Aklavik-Caribou Hills second year series there is a joint non-overlap of 90 per cent, and between the first year series from these places, 91 per cent. The latter is reduced to 88 per cent when the skull depth is adjusted to a mean condylobasal length of 22.5 mm. If, as here supposed, the Tuktoyaktuk population is only subspecifically distinct from *C.r. dawsoni*, some tendency for the skulls of a population adjacent to Tuktoyaktuk to average flatter than those of the southwest area might be expected, and in fact Table VI and Figures 7 and 15 show that this

is true for the Aklavik-Caribou Hills population, at least in the adjusted measurements¹. However, it is possible that this is an independent variation and not a gradation toward the Tuktoyaktuk population, a hypothesis that is strengthened by the slightly greater (.07 mm.) mean skull depth of the 15 Caribou Hills second year mice when compared to the seven Aklavik specimens, in spite of the fact that the Caribou Hills are geographically nearly mid way between Aklavik and Tuktoyaktuk. Compared to the obvious difference between the Tuktoyaktuk series and those of the neighbouring populations of *C.r. dawsoni* in the Caribou Hills and Aklavik region, the similarity in the skull depth of the Tuktoyaktuk population and the distant *C.r. jochelsoni* is most striking. The small difference, .16 mm., in the unadjusted means of the adult series of these populations is not technically significant ($t=1.9$, $P>.05$), but as it is supported by the adjusted and unadjusted means of the combined first and second year series, there is a strong presumption that all classes of the Tuktoyaktuk population have, on the average, slightly flatter skulls than *C.r. jochelsoni*, which in turn seems to be the flattest-skulled palaeartic race (Ognev, 1954).

The deep skulls of the second year *C.r. washburni* are partly a function of their large total size, but there is an indication that the adjusted depth of second year and older first year animals of that race may also be slightly greater. In any case, it is quite obvious that in this character at least they, as well as other eastern barren ground specimens, particularly Coronation Gulf and Smoke Lake specimens, show no affinity with the Tuktoyaktuk population. Also obviously unrelated are two first and two second year mice from Umiat on the west coast (See Figure 15). A single second year Point Barrow specimen with a condylobasal length of 24.7 mm. and a skull depth of 8.8 mm. is rather flat-headed, but nonetheless outside the range of the Tuktoyaktuk series although well within that of the Aklavik and southwestern region series.

Some of the differences amongst the coefficients of regression in Table VI are larger than would be expected from errors of chance sampling. For instance, in the first year group, the regression of the Tuktoyaktuk series is significantly less than that of the Aklavik series ($t=2.3$, P about .03) or the small *C.r. washburni* series ($t=2.3$, P about .03). It is not by any means yet clear to what extent these differences in regression coefficients may indicate geographically distributed genetic differences rather than differences in age and season of capture of the samples, but inspection of Figure 15 indicates that the regression coefficient of the sum of the first and second year *dawsoni-washburni* specimens would be significantly greater than the sum of the first and second year Tuktoyaktuk-Siberia specimens, another indication of the marked difference between the two groups. Owing to the small number of second year *C.r. washburni* available, the regression coefficient of the combined first and second year mice of that race has not been calculated, but the large mean skull depth, 9.32 mm., of the second year specimens indicates that it would be comparatively high, and the six Coronation Gulf specimens tentatively referred to *C.r. washburni* actually lie along the prolongation of the regression line of the first year series (See Figure 15). On the other hand, the inclusion of eight second year

¹ $t=2.2$, $P<.05$, for a comparison of the adjusted means of the combined first and second year Aklavik and southwestern series.

mice with the 64 specimens of Aklavik first year series has so reduced the regression coefficient that it is clearly no longer significantly different from that of the Tuktoyaktuk series, the coefficient of which is not changed by the addition of the ten adults (Table VI). At the same time, the difference between the regression coefficients of Aklavik first year mice and Aklavik combined first and second year mice amounts to .09: $t=1.9$, P just over .05.

Zygomatic breadth (Table VII, Figures 8, 16). It is evident (Figure 8) that the absolute zygomatic breadth of the second year series of the Perry River and Aylmer and Clinton-Colden lakes population of *C.r. washburni* is significantly greater ($t=3.0$, $P<.01$) than that of the Aklavik-Caribou Hills population of *C.r. dawsoni*, which has the next broadest zygoma. The mean adjusted zygomatic width of the second year *C.r. washburni* is also greater, and the small series from Coronation Gulf (Figure 16) agrees in this respect with the more obviously typical series of that race. The difference in zygomatic breadth of second year mice from the other populations measured is principally a function of their total size (condylobasal length).

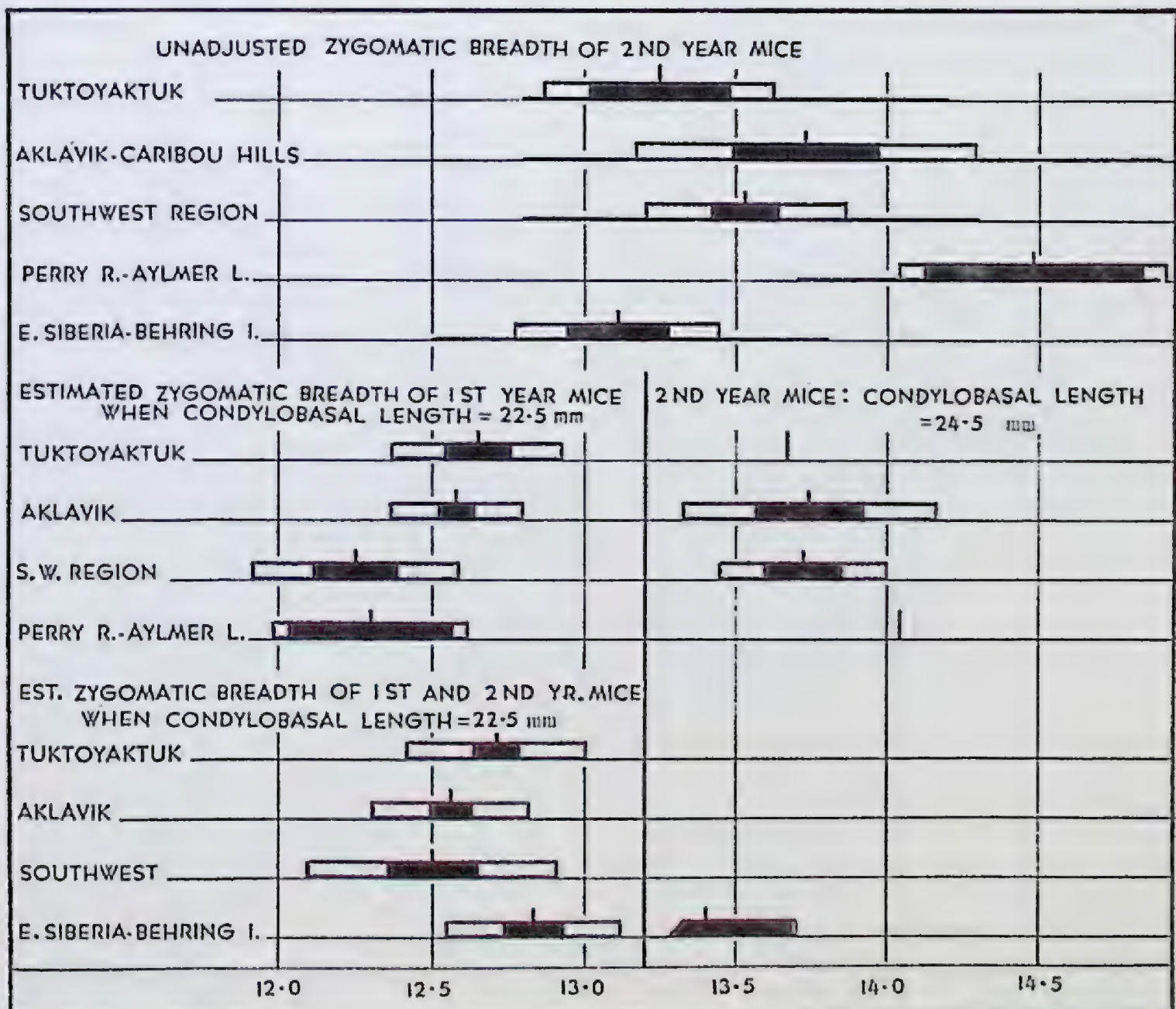


Figure 8. Zygomatic breadths plotted from figures derived from Table VII. (See Figure 7 for explanation.)

TABLE VII
 Estimated parameters for zygomatic breadth Y and its correlation with and regression on condylobasal length X
 (See Table VI for formulae)

Race	Origin	Period	No.	Range	Mean	S.D.	C.V.	r	z	b_{yx}	S_{yx}	\bar{y} when $\bar{x} = 24.5$
Second year mice												
New subspecies..	Tuktoyaktuk.....	Oct.	11	12.8-14.2	13.25 ± .110	.37 ± .09	2.8 ± .59	—	—	.40 assumed	—	13.67 ¹
<i>C.r. dawsoni</i> ...	Aklavik-Caribou Hills	June-Nov.	22	12.8-14.9	13.73 ± .116	.54 ± .09	3.9 ± .60	.68	.83 ± .23	.56 ± .136	.42	13.74 ± .090
<i>C.r. dawsoni</i> ...	Southwest region..	June-Aug.	40	12.8-14.3	13.53 ± .053	.33 ± .037	2.4 ± .28	.54	.60 ± .17	.33 ± .083	.28	13.72 ± .066
<i>C.r. washburni</i> ...	Perry R.-Aylmer L.	July-Aug.	6	13.7-14.9	14.48 ± .164	.40 ± .116	2.8 ± .81	—	—	.40 assumed	—	14.04 ²
<i>C.r. jochelsoni</i> ...	E. Siberia (13)-Behring I. (3)	Chiefly winter	16	12.5-13.8	13.11 ± .082	.33 ± .058	2.5 ± .44	.52	.58 ± .28	.30 ± .131	.30	13.40 ± .143
First year mice												
New subspecies..	Tuktoyaktuk.....	Sept.-Nov.	77	11.3-13.2	12.28 ± .043	.38 ± .031	3.1 ± .26	.68	.83 ± .12	.45 ± .055	.28	$\bar{x} = 22.5$ 12.65 ± .055
<i>C.r. dawsoni</i> ...	Aklavik.....	Sept.-Nov.	66	12.1-13.7	12.68 ± .035	.28 ± .025	2.2 ± .20	.63	.74 ± .13	.35 ± .054	.22	12.58 ± .032
<i>C.r. dawsoni</i> ...	Southwest region..	June-Nov.	22	11.2-13.3	12.24 ± .123	.57 ± .087	4.7 ± .71	.83	1.19 ± .23	.47 ± .071	.34	12.25 ± .072
<i>C.r. washburni</i> ..	Perry R.-Aylmer L.	Aug.-Sept.	13	11.9-13.2	12.58 ± .108	.38 ± .076	3.1 ± .60	.64	.76 ± .32	.44 ± .160	.32	12.30 ± .136
Second + first year mice												
New subspecies..	Tuktoyaktuk.....	Sept.-Nov.	10+77	11.3-14.2	12.40 ± .054	.50 ± .038	4.0 ± .31	.81	1.13 ± .11	.50 ± .040	.30	12.71 ± .040
<i>C.r. dawsoni</i> ...	Aklavik.....	Sept.-Nov.	8+66	12.1-14.5	12.79 ± .052	.44 ± .037	3.5 ± .29	.82	1.16 ± .12	.47 ± .039	.26	12.56 ± .036
<i>C.r. dawsoni</i> ...	Southwest region..	June-Sept.	40+17 ³	11.2-14.3	13.11 ± .102	.77 ± .072	5.9 ± .55	.86	1.29 ± .14	.64 ± .053	.41	12.50 ± .074
<i>C.r. jochelsoni</i> ...	E. Siberia (57)-Behring I. (3)	Chiefly winter	15+45	12.3-14.0	13.04 ± .046	.35 ± .033	2.7 ± .25	.60	.69 ± .14	.33 ± .058	.29	12.83 ± .052

¹ 10 specimens.

² 4 specimens.

³ Norman Wells specimens omitted.

In the first year series there are some obvious differences in the adjusted means. These differences, however, do not have a genetic basis but are related to the season at which the specimens were taken. This is presumably due to the continued growth (strengthening and arching) of the zygoma during the winter interruption of longitudinal growth. The same conclusion may be drawn from the fact that the means of the second year specimens (Figure 16) all lie above the projected regression lines of the first year specimens.¹ The regression line of the mixed series of first and second year *C.r. jochelsoni*, however, lies above that of the second year series of that race. This is also to be expected if, as is thought, all the first year specimens were taken in the autumn, winter, and early spring, when the zygomatic breadth is relatively at a maximum. The large relative zygomatic breadth of the six Coronation Gulf specimens may in part be similarly accounted for. These were taken between March 26 and May 26. One may be over a year old. Also, the mean of the six November first year Norman Wells specimens lies not on the regression line of the southwestern summer series, but on that of the November Aklavik series; this in spite of the inclusion of five of the Norman Wells specimens in the southwestern series. With these five omitted, the regression line of the southwest series still has the same slope, but its position is lower. Some change in relative growth rate of the zygoma may already have commenced when the Victory Lake (August 12-14)–Smoke Lake (August 21-23) specimens were taken.

Considerable differences in the coefficient of regression of mixed series of first and second year specimens are to be expected according to the season and to the proportion of the two age groups present. The difference between the coefficient of regression of the Aklavik and Caribou Hills second year series, and that of the second year southwestern region series or the second year *C.r. jochelsoni* series, is rather large, but in neither case significant ($t=1.6$, P about .1, and $t=1.3$, P about .2).

Lambdoidal breadth (Table VIII, Figures 9, 17). The measurements here used may be defined as the greatest breadth across the skull between the extremities of the ridges formed as a prolongation of the lambdoidal crest at the junction of the squamosal and mastoid bones. It is an easy measurement to take, but careless or excessive cleaning of the specimens can appreciably reduce the ridges.

With a few exceptions, the regression lines of lambdoidal breadth on condylobasal length (Figure 17) occupy the same relative positions as those of zygomatic breadth on condylobasal length (Figure 16). It may be supposed that to a large extent this is due to correlation between the two breadth measurements in individual skulls, and the similarity in the relative positions of the regression lines can therefore only be considered significant to the extent that the differences between the positions of the regression lines on either figure are significant: that is to say, graphs for the two measurements drawn from a second set of samples, though again showing the correspondence in the relative positions of the regression lines, might both differ markedly from the present graphs. However, it appears certain that there is an increase in lambdoidal breadth during the winter when there is little or no condylobasal growth, although this increase may be less

¹This might be due, and in part probably is due, to a continued broadening of the zygoma after growth in condylobasal length has stopped for life.

TABLE VIII
 Estimated parameters in mm. lambdoidal breadth Y and its correlation with and regression on condylobasal length X
 (See Table VI for formulae)

Race	Origin	Period	No.	Range	Mean	S.D.	C.V.	r	z	b_{yx}	S_y	\bar{y} when $\bar{x} = 24.5$
Second year mice												
New subspecies.	Tuktoyaktuk.....	Oct.	11	10.7-11.5	11.12 ± .078	.26 ± .056	2.3 ± .50	—	—	.34 assumed	—	11.46 ¹
<i>C.r. dawsoni</i> ...	Aklavik-Caribou Hills	July-Nov.	22	11.0-12.2	11.68 ± .066	.31 ± .047	2.6 ± .40	.84	1.21 ± .23	.39 ± .058	.18	11.69 ± .038
<i>C.r. dawsoni</i> ...	Southwest region..	July-Aug.	40	10.9-12.0	11.51 ± .047	.29 ± .033	2.6 ± .29	.58	.66 ± .17	.31 ± .071	.24	11.69 ± .057
<i>C.r. washburni</i> ...	Perry R.-Aylmer L.	July-Aug.	5	11.6-12.2	11.91 ± .104	.23 ± .074	1.9 ± .62	—	—	.34 assumed	—	11.57 ²
<i>C.r. jochelsoni</i> ...	E. Siberia (13)-Behring I. (3)	Chiefly winter	16	10.8-11.9	11.24 ± .069	.27 ± .049	2.4 ± .44	.67	.83 ± .28	.32 ± .096	.22	11.54 ± .105
First year mice												
New subspecies.	Tuktoyaktuk.....	Sept.-Nov.	77	9.7-11.1	10.53 ± .032	.28 ± .023	2.7 ± .22	.69	.86 ± .12	.33 ± .041	.21	$\bar{x} = 22.5$ 10.80 ± .041
<i>C.r. dawsoni</i> ...	Aklavik.....	Sept.-Nov.	66	10.4-11.6	11.12 ± .031	.25 ± .022	2.2 ± .20	.65	.78 ± .13	.32 ± .046	.19	11.03 ± .027
<i>C.r. dawsoni</i> ...	Southwest region..	June-Nov.	22	9.9-11.7	10.85 ± .080	.37 ± .057	3.5 ± .52	.80	.97 ± .23	.29 ± .051	.24	10.86 ± .051
<i>C.r. washburni</i> ...	Perry R.-Aylmer L.	Aug.-Sept.	13	10.5-11.6	11.05 ± .082	.29 ± .058	2.7 ± .52	.87	1.33 ± .32	.45 ± .079	.16	10.76 ± .067
Second + first year mice												
New subspecies.	Tuktoyaktuk.....	Sept.-Nov.	10+77	9.7-11.4	10.60 ± .036	.33 ± .026	3.1 ± .24	.77	1.01 ± .11	.32 ± .029	.22	10.79 ± .029
<i>C.r. dawsoni</i> ...	Aklavik.....	Sept.-Nov.	8+66	10.4-12.0	11.19 ± .036	.31 ± .026	2.8 ± .23	.80	1.11 ± .12	.32 ± .029	.19	11.03 ± .026
<i>C.r. dawsoni</i> ...	Southwest region..	June-Sept.	40+17 ³	9.9-12.0	11.31 ± .060	.45 ± .043	4.0 ± .38	.83	1.19 ± .14	.37 ± .033	.25	10.96 ± .047
<i>C.r. jochelsoni</i> ...	E. Siberia (57)-Behring I. (3)	Chiefly winter	15+45	10.6-11.9	11.18 ± .036	.27 ± .026	2.5 ± .23	.66	.83 ± .14	.28 ± .042	.21	11.00 ± .038

¹ 10 specimens.

² 4 specimens.

³ Norman Wells specimens omitted.

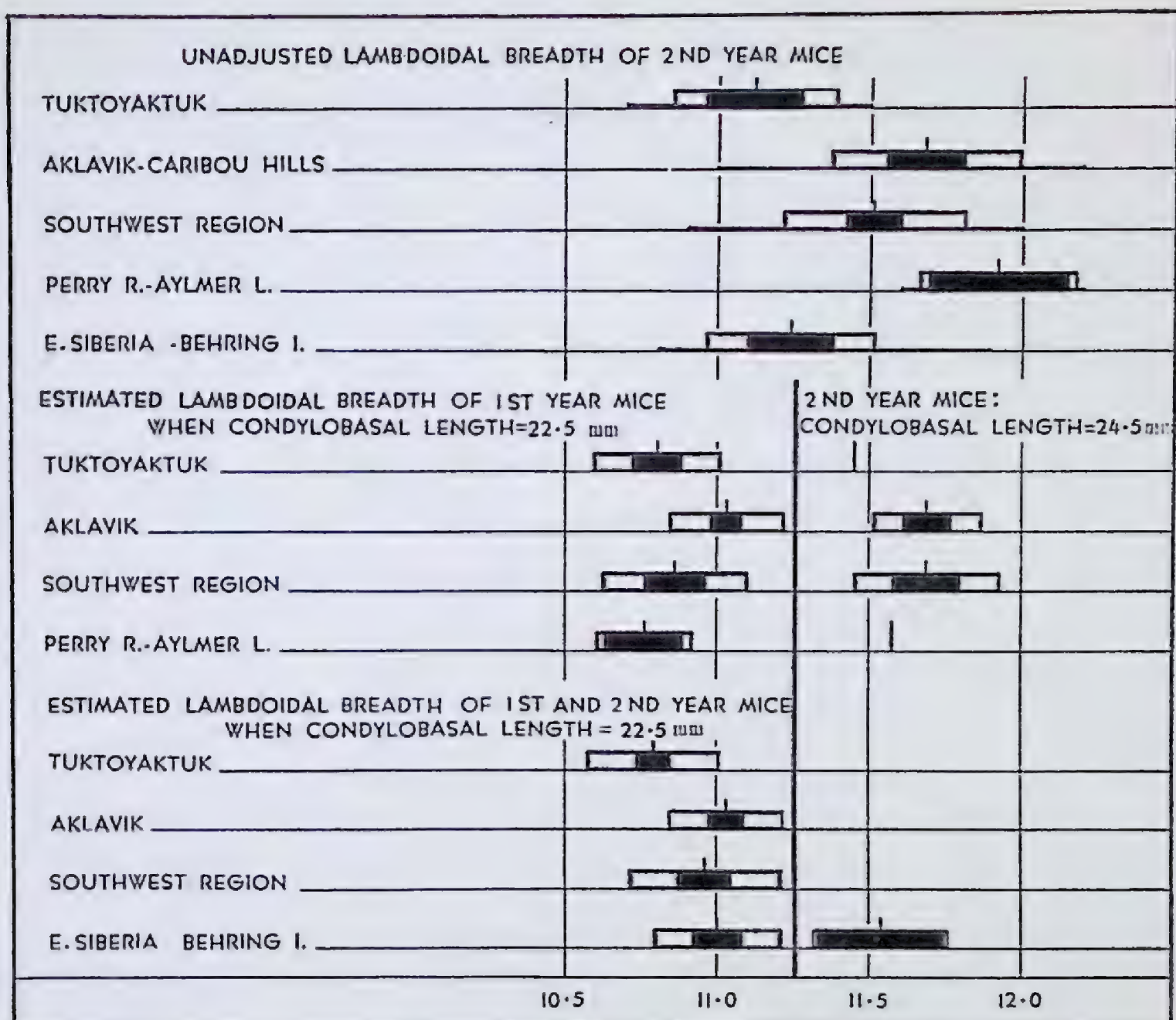


Figure 9. Lambdoidal breadths plotted from figures derived from Table VIII. (See Figure 7 for explanation).

marked than that of zygomatic breadth. The most obvious difference in the relative positions of the regression lines of lambdoidal and zygomatic breadth on condylobasal length is caused by the Tuktoyaktuk series, which has a relatively large mean zygomatic breadth but small lambdoidal breadth both in first and in second year series. Moreover, the mean adjusted and unadjusted lambdoidal breadths of the Tuktoyaktuk series are clearly (Figure 9) significantly smaller than the equivalent Aklavik means. It appears that this difference must be genetic.

There are no significant differences between any of the regression coefficients in Table VIII. Individual variation in lambdoidal breadth is smaller than in zygomatic breadth, and there is less difference between the first and second year series.

Crown length of the maxillary tooth row (Table IX, Figures 10, 18). In old age the crown length of the rooted molar teeth of *C. rutilus* is shortened by wear. This reduces the value of the measurements for comparisons of second year mice, particularly as there is a considerably higher proportion of specimens with worn teeth in late summer and autumn

TABLE IX
Estimated parameters in mm. for lengths of maxillary tooth row Y and its correlation with and regression on condylobasal length X
(See Table VI for formulae)

Race	Origin	Period	No.	Range	Mean	S.D.	C.V.	r	z	b_{yx}	S_{yx}	\bar{y} when $\bar{x} = 24.5$
Second year mice												
New subspecies...	Tuktoyaktuk.....	Oct.	7	4.6-4.8	4.70 ± .035	.09 ± .025	1.2 ± .33	—	—	.11 assumed	—	4.82 ¹
<i>C.r. dawsoni</i>	Aklavik-Caribou Hills	June-Nov.	17	4.5-5.2	4.78 ± .043	.18 ± .031	3.7 ± .64	.45	.48 ± .27	.12 ± .062	.17	4.78 ± .041
<i>C.r. dawsoni</i>	Southwest region.....	June-Aug.	40	4.5-5.2	4.82 ± .028	.18 ± .020	3.7 ± .41	.32	.33 ± .17	.10 ± .050	.17	4.88 ± .040
<i>C.r. washburni</i> ...	Perry R.-Aylmer L.....	July-Aug.	9	4.9-5.5	5.24 ± .057	.17 ± .041	3.3 ± .77	—	—	.11 assumed	—	5.21 ²
<i>C.r. jacksoni</i>	E. Siberia (8)- Behring I. (1)	Chiefly winter	9	4.2-4.6	4.46 ± .039	.12 ± .028	2.6 ± .62	—	—	.11 assumed	—	4.59
First year mice												
New subspecies...	Tuktoyaktuk.....	Sept.-Nov.	77	4.2-4.8	4.49 ± .016	.14 ± .011	3.0 ± .28	.55	.62 ± .12	.13 ± .023	.12	$\bar{x} = 22.5$ 4.60 ± .023
<i>C.r. dawsoni</i>	Aklavik.....	Sept.-Nov.	66	4.5-5.0	4.68 ± .015	.12 ± .011	2.6 ± .23	.19	.20 ± .13	.05 ± .029	.12	4.66 ± .017
<i>C.r. dawsoni</i>	Southwest region.....	June-Nov.	22	3.9-4.7	4.40 ± .048	.22 ± .034	5.1 ± .77	.72	.91 ± .23	.16 ± .035	.16	4.40 ± .035
<i>C.r. washburni</i> ...	Perry R.-Aylmer L.....	Aug.-Sept.	13	4.4-4.9	4.62 ± .037	.13 ± .026	2.8 ± .56	.53	.59 ± .32	.12 ± .060	.12	4.54 ± .051
Second + first year mice												
New subspecies...	Tuktoyaktuk.....	Sept.-Nov.	6+77	4.2-4.8	4.51 ± .017	.15 ± .012	3.2 ± .26	.64	.76 ± .12	.12 ± .017	.11	4.59 ± .017
<i>C.r. dawsoni</i>	Aklavik-Caribou Hills	June-Nov.	66+17	4.5-5.2	4.70 ± .015	.14 ± .011	3.0 ± .23	.39	.41 ± .12	.06 ± .016	.13	4.62 ± .026
<i>C.r. dawsoni</i>	Southwest region.....	June-Sept.	40+17 ³	3.9-5.2	4.68 ± .039	.29 ± .027	6.2 ± .58	.78	1.04 ± .14	.22 ± .024	.18	4.47 ± .034
<i>C.r. jacksoni</i>	E. Siberia (52)- Behring I. (1)	Chiefly winter	8+45	4.2-4.9	4.58 ± .020	.14 ± .014	3.2 ± 3.1	.26	.26 ± .15	.06 ± .033	.14	4.55 ± .027

¹ 6 specimens.
² 5 specimens.
³ Norman Wells specimens omitted.

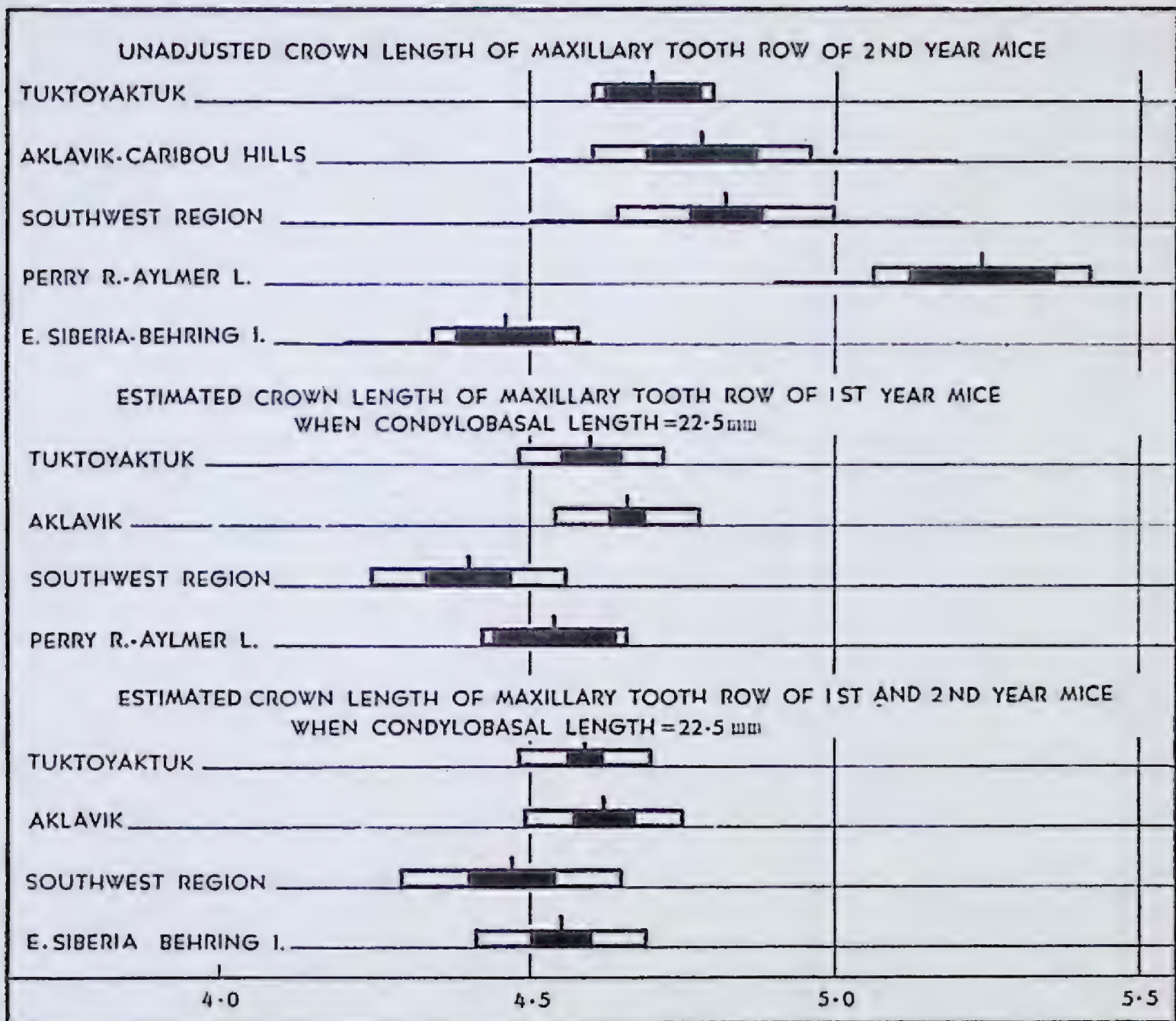


Figure 10. Maxillary tooth row lengths plotted from figures derived from Table IX. (See Figure 7 for explanation).

collections than in those taken in early summer. It is difficult to say at what stage wear begins to affect the length of the crown, and ideally no specimens showing external evidence of rooting in the upper jaw should be included. However, this would virtually eliminate the Tuktoyaktuk second year series. Alveolar length, although a more difficult measurement to take, might be more suitable for this species.

The problem of tooth wear was not considered from the point of view of crown length comparisons when the skulls were originally classed for age, but the older specimens were divided into two groups: (1) teeth worn, (2) teeth very worn. Since wear first shows in the mandibular row, it is believed that serious reduction in maxillary row length would occur only in the 'very worn' teeth. Teeth classed as 'very worn' have therefore been eliminated from all series. Four mice with 'worn' teeth remain in the small Tuktoyaktuk second year series, one in the southwest second year series, and four in the east Siberia-Behring Island series. If the 'worn' specimens are eliminated, the mean size of the remaining three Tuktoyaktuk specimens is only 4.73 mm., and of the four *C.r. jochelsoni*, 4.53 mm. The mean

length of the mandibular tooth row of the four 'very worn' Tuktoyaktuk specimens is 4.53 mm., of the seven 'very worn' *C.r. jochelsoni*, 4.20 mm.

As pointed out by Hanson (1952), the maxillary tooth row of adult (here second year) *C.r. washburni* averages longer than that of *C.r. dawsoni*. Table IX and Figure 18 also indicate that the position of the regression line would also be higher. The same is true of the first year *C.r. washburni* when compared with the summer first year mice from the southwest area. However, the adjusted tooth row lengths of both the first year *C.r. washburni* series and the southwest region first year series are distinctly shorter than the Tuktoyaktuk and Aklavik autumn series (Figure 10). This fact, together with the distance between the regression lines of the first and second year southwest region series and between the extended regression line of the first year *C.r. washburni* and the mean of the second year series, indicates an early autumn increase in the differential relative growth of the maxillary tooth row. This increase may be associated with a need for a larger grinding surface during the winter months when more, and perhaps coarser, food is presumably consumed. The fact that the mandibular tooth row of combined first and second year *C.r. jochelsoni*, most of which were taken during the winter, is slightly longer than that of the second year specimens alone (Table IX) is another indication that considerable growth in the tooth row length must occur in early winter. Further support for this is given by the low regression coefficients for the Aklavik first year series and the combined first and second year *C.r. jochelsoni* series which was taken chiefly in winter. The fact that the regression coefficient of the first year Tuktoyaktuk series is significantly ($t=2.5$, $P<.02$) higher than that of the Aklavik presumably indicates that tooth crown length was increasing during October, when most of the Tuktoyaktuk series was taken, but that growth had almost ceased by the latter part of November, when most of the Aklavik series was caught. It might be expected that second year specimens would show the same low regression coefficient as the first year autumn specimens. Actually, the agreement is not particularly close. However, the difference between the regression coefficients of the Aklavik-Caribou Hills second year mice and the Aklavik first year series is not significant ($t=1.3$, P about .2), and the same probably applies to the Aklavik first year and the southwest region second year series. Also, the comparatively high regression coefficient of these adults could have been caused by the erroneous inclusion of a few large first year specimens.

The comparatively slight variation between the mandibular tooth row length of first and second year and between large and small autumn specimens means that, providing those with worn teeth are eliminated, the whole collection taken at that time of year may be grouped together for comparison with a similar collection of another population. First year summer specimens, however, should not be compared with similar-sized autumn or winter material.

Diastema (Tables X, XI; Figures 11, 12, 19, 20). The diastema was measured from the distal border of the alveolus of the first upper molar to the posterior border of the alveolus of the incisor, using the internal measuring points of the calipers. When the teeth were firmly rooted, the calipers were allowed to touch the surface of the teeth. Of the measurements here considered, this was the most difficult to take consistently.

TABLE X

Estimated parameters in mm. for diastema length Y and its correlation with and regression on condylobasal length X

(See Table VI for formulae)

Race	Origin	Period	No.	Range	Mean	S.D.	C.V.	r	z	b_{yx}	S_{yx}	\bar{y} when $\bar{x} = 24.5$
Second year mice												
New subspecies.	Tuktoyaktuk.	Oct.	11	7.1-7.8	7.31 ± .061	.20 ± .044	2.8 ± .59	—	—	.38 assumed	—	7.68 ¹
<i>C.r. dawsoni</i>	Aklavik-Caribou Hills	July-Nov.	22	7.3-8.1	7.79 ± .055	.26 ± .039	3.3 ± .50	.75	.97 ± .23	.30 ± .059	.18	7.80 ± .038
<i>C.r. dawsoni</i>	Southwest region.	July-Aug.	40	6.8-8.1	7.51 ± .047	.29 ± .033	3.9 ± .44	.71	.89 ± .17	.38 ± .062	.21	7.71 ± .049
<i>C.r. washburni</i>	Perry R.-Aylmer L.	July-Aug.	8	7.3-8.4	7.88 ± .123	.35 ± .087	4.4 ± 1.10	—	—	.38 assumed	—	7.53 ²
<i>C.r. jochelsoni</i>	E. Siberia (13)- Behring I. (3)	Chiefly winter	16	7.0-8.1	7.46 ± .073	.29 ± .052	3.9 ± .69	.91	1.53 ± .29	.46 ± .058	.13	7.90 ± .064
First year mice												
New subspecies.	Tuktoyaktuk.	Sept.-Nov.	77	5.9-7.1	6.50 ± .030	.27 ± .022	4.1 ± .33	.88	1.35 ± .12	.40 ± .026	.13	6.82 ± .026
<i>C.r. dawsoni</i>	Aklavik.	Sept.-Nov.	66	6.5-7.8	7.01 ± .028	.22 ± .020	3.2 ± .28	.81	1.13 ± .13	.35 ± .033	.13	6.91 ± .019
<i>C.r. dawsoni</i>	Southwest region.	June-Nov.	22	6.1-7.6	6.94 ± .081	.38 ± .060	5.5 ± .79	.93	1.68 ± .23	.35 ± .031	.14	6.95 ± .031
<i>C.r. washburni</i>	Perry R.-Aylmer L.	Aug.-Sept.	13	6.8-7.7	7.12 ± .069	.25 ± .049	3.5 ± .69	.81	1.14 ± .14	.36 ± .078	.16	6.89 ± .066
Second + first year mice												
New subspecies.	Tuktoyaktuk.	Sept.-Nov.	10+77	5.9-7.8	6.59 ± .040	.37 ± .028	5.6 ± .43	.94	1.71 ± .11	.43 ± .018	.13	6.85 ± .018
<i>C.r. dawsoni</i>	Aklavik.	Sept.-Nov.	8+66	6.5-8.1	7.11 ± .041	.35 ± .029	5.0 ± .41	.93	1.66 ± .12	.43 ± .020	.13	6.90 ± .018
<i>C.r. dawsoni</i>	Southwest region.	June-Sept.	40+17 ³	6.1-8.1	7.32 ± .058	.43 ± .041	5.9 ± .56	.90	1.45 ± .14	.38 ± .026	.20	6.95 ± .036
<i>C.r. jochelsoni</i>	E. Siberia (57)- Behring I. (3)	Chiefly winter	15+45	6.5-8.1	7.16 ± .046	.35 ± .032	4.9 ± .45	.87	1.33 ± .14	.47 ± .036	.18	6.87 ± .032

¹ 10 specimens.² 4 specimens.³ Norman Wells specimens omitted.

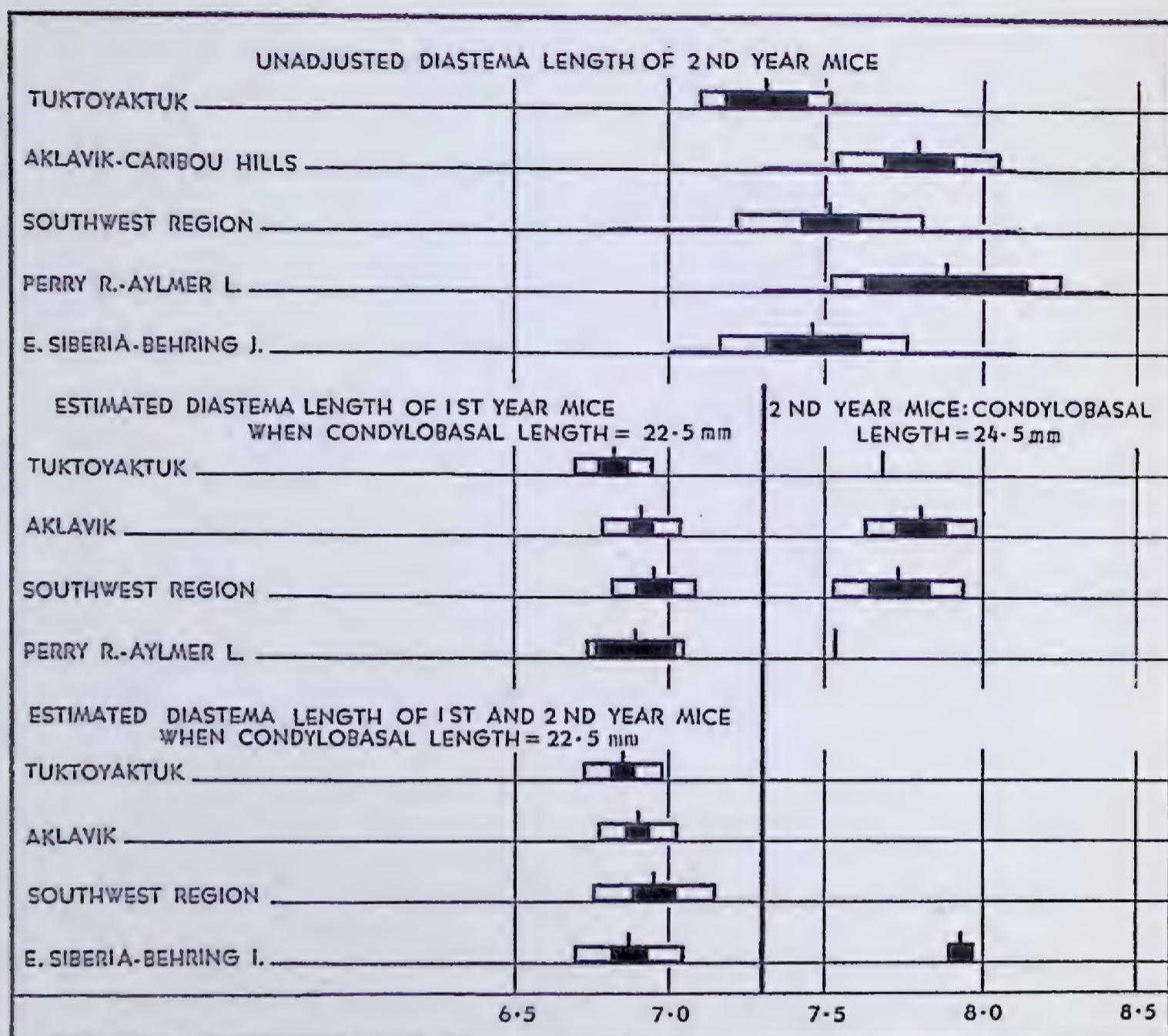


Figure 11. Diastema lengths plotted from figures derived from Table X. (See Figure 7 for explanation).

The high correlation between diastema length and condylobasal length is partly spurious in that the former is clearly an essential part of the latter in a way that is not necessarily true of the maxillary tooth row crown length or of the nasal length, although these measurements are also taken along approximately the same axis. It therefore seemed worth correlating diastema length with condylobasal length minus diastema length, in spite of the loss of accuracy which must accrue when one measurement is correlated with another minus itself¹. To avoid the laborious process of complete re-calculation, the sum of squares and products for the new measurements were obtained by the following formulae: $\Sigma d_x'^2 = \Sigma d_x^2 + \Sigma d_y^2 - \Sigma d_x d_y$, and $\Sigma d_x d_y' = \frac{1}{2}(\Sigma d_x^2 - \Sigma d_y^2 - \Sigma d_x'^2)$, derived from those given by Clark (1941, p. 285) for obtaining correlation directly in similar circumstances. As this formula involves subtractions and as the slide rule

¹There is also the disadvantage that part of the premaxilla is left with the independent variate condylobasal minus diastema length. If this work were repeated, two measurements, one designed to give the length of the proximal portion of the skull, and one that of the whole distal portion, would probably be found more useful than the diastema length.

TABLE XI
 Estimated parameters in mm. for diastema length Y and its correlation with and regression on condylobasal length
 minus diastema length X

(See Table VI for formulae)

Race	Origin	Period	No.	r	z	b_{yx}	S_{yx}	\bar{y} when $\bar{x} = 16.5$
Second year mice								
<i>C.r. dawsoni</i>	Aklavik-Caribou Hills.....	July-Nov.	22	.47	.52 ± .23	.25 ± .104	.24	7.30 ± .055
<i>C.r. dawsoni</i>	Southwest region.....	July-Aug.	40	.23	.24 ± .17	.17 ± .116	.29	7.52 ± .057
<i>C.r. jochelsoni</i>	E. Siberia (13)-Behring I. (3)...	Chiefly winter	16	.67	.80 ± .29	.58 ± .175	.23	7.70 ± .092
First year mice								
New subspecies.....	Tuktoyaktuk.....	Sept.-Nov.	77	.65	.78 ± .12	.47 ± .066	.20	$\bar{x} = 15.6$ 6.69 ± .035
<i>C.r. dawsoni</i>	Aklavik.....	Sept.-Nov.	66	.52	.58 ± .13	.33 ± .068	.20	6.94 ± .027
<i>C.r. dawsoni</i>	Southwest region.....	June-Nov.	22	.84	1.22 ± .23	.47 ± .070	.22	6.97 ± .093
<i>C.r. washburni</i>	Perry R.-Aylmer L.....	Aug.-Sept.	13	.53	.60 ± .14	.34 ± .163	.23	6.97 ± .048
Second + first year mice								
New subspecies.....	Tuktoyaktuk.....	Sept.-Nov.	10+77	.80	1.10 ± .11	.61 ± .066	.29	$\bar{x} = 16.0$ 7.02 ± .056
<i>C.r. dawsoni</i>	Aklavik.....	Sept.-Nov.	8+66	.79	1.07 ± .12	.61 ± .057	.22	7.18 ± .027
<i>C.r. dawsoni</i>	Southwest region.....	June-Sept.	40+17 ¹	.73	.92 ± .19	.48 ± .061	.31	7.25 ± .042
<i>C.r. jochelsoni</i>	E. Siberia (57)-Behring I. (3)...	Chiefly winter	15+45	.55	.62 ± .14	.50 ± .099	.30	7.18 ± .040

¹ Norman Wells specimens omitted.

calculations could be taken to only three figures, some loss of accuracy undoubtedly occurred, but two check calculations from the original figures give a difference in the coefficient of regression of only .01 and .02 respectively. Since the diastema means do not change, the general position of the new regression lines in Figure 20 remains the same as in Figure 19. There is a greater difference in slope between the regression lines for *C.r. jochelsoni* and the Aklavik-Caribou Hills second year series, but, because of the low correlation between the diastema length and condylobasal minus diastema length, this difference is no more significant ($t=1.6$, P about .1) than it is when the condylobasal length is used as the independent variate (i.e., $t=1.9$, $P<.1>.05$). The difference between the correlation coefficients of *C.r. jochelsoni* and the southwest region second year mice, when the condylobasal minus diastema length is the independent variate, is also not significant ($t=1.7$, P about .1).

It is apparent from Figures 19 and 20, that the means of the adult (second year) series lie well above the regression lines of the first year series. Since the regression lines of the autumn Tuktoyaktuk and Aklavik first year series and the winter *C.r. jochelsoni* series do not in any case lie appreciably

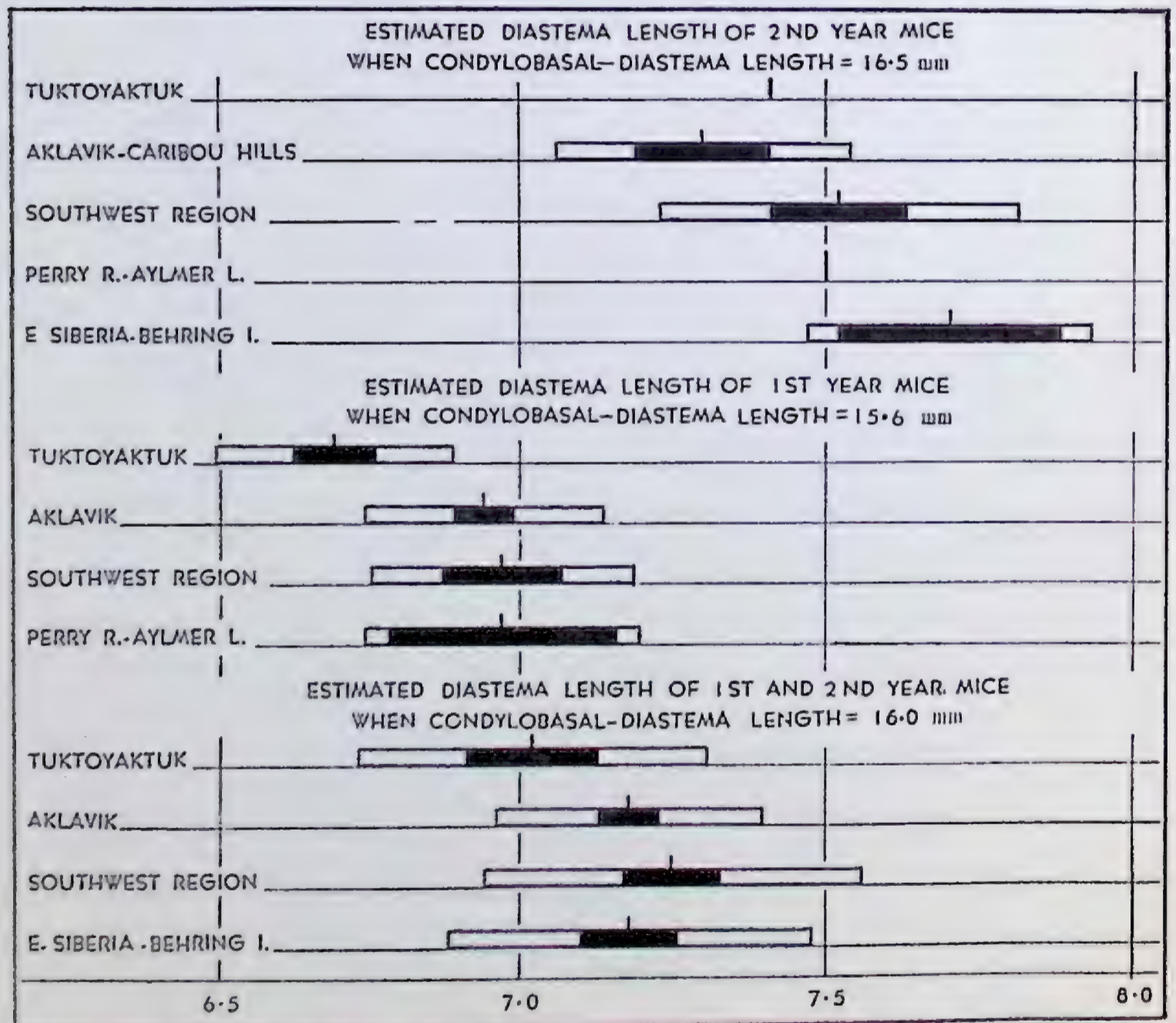


Figure 12. Diastema lengths adjusted to fixed condylobasal length minus diastema length plotted from figures derived from Table XI. (See Figure 7 for explanation).

above the southwest region first year summer series, it is probable that this growth occurs in late winter or early spring rather than in the autumn or early winter¹. In fact, most of the difference in condylobasal length between southwest region second year June specimens and July to early September second year specimens lies in the diastema (See Figure 20), and a good part of the remaining difference may also be in the forward portion of the skull. Hence small diastema length relative to the length of the posterior portion of the skull, perhaps from M3 to the occipital condyle, may be another indication of the age of late summer specimens.

The diastema of the Tuktoyaktuk population averages distinctly shorter in absolute measurement than that of other populations sampled, and about 81 per cent first year and 78 per cent second year mice are separable from the same percentages of the Aklavik series. The adjusted

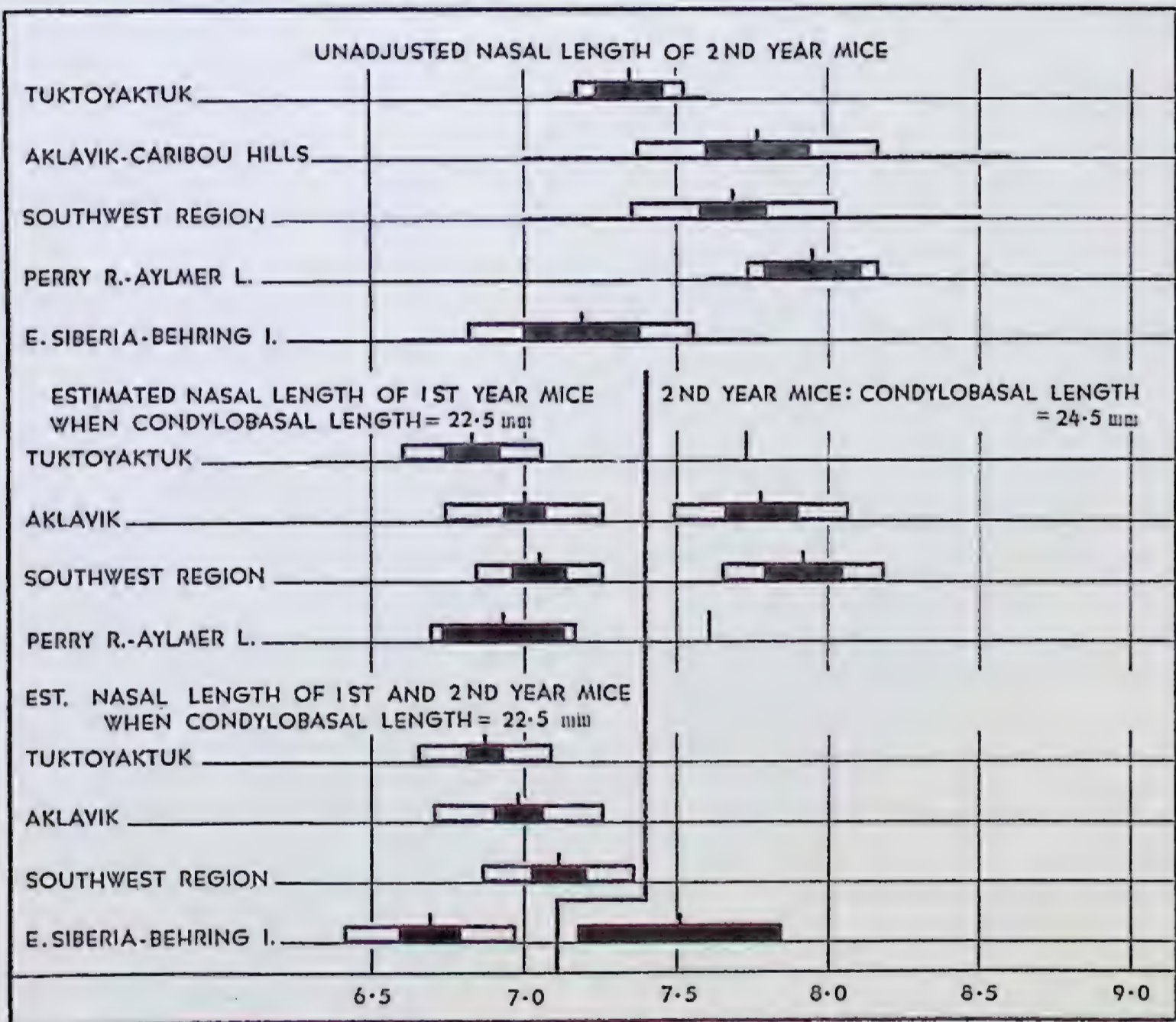


Figure 13. Nasal lengths plotted from figures derived from Table XII. (See Figure 7 for explanation).

¹The large diastema length of the six November Norman Wells specimens is an argument against this. However, the difference, .32 mm., in diastema length between these and the remaining 17 southwest region first year mice is not significant ($t = 1.8$, P about .1), even when the larger condylobasal length of the Norman Wells specimens is neglected.

TABLE XII
 Estimated parameters in mm. for nasal length Y and its correlation with and regression on condylobasal length X
 (See Table VI for formulae)

Race	Origin	Period	No.	Range	Mean	S.D.	C.V.	r	z	b_{yx}	S_{yx}	\bar{y} when $\bar{x}=24.5$
Second year mice												
New subspecies...	Tuktoyaktuk.....	Oct.	11	7.1-7.6	7.35 ± .052	.17 ± .037	2.4 ± .50	—	—	.38 assumed	—	7.73 ¹
<i>C.r. dawsoni</i>	Aklavik-Caribou Hills	July-Nov.	22	7.0-8.6	7.77 ± .083	.39 ± .059	5.0 ± .76	.72	.90 ± .23	.43 ± .093	.29	7.78 ± .061
<i>C.r. dawsoni</i>	Southwest region.....	July-Aug.	40	7.0-8.5	7.69 ± .053	.33 ± .038	4.3 ± .49	.61	.72 ± .17	.37 ± .078	.27	7.91 ± .063
<i>C.r. washburni</i> ...	Perry R.-Aylmer L.....	July-Aug.	8	7.6-8.2	7.95 ± .073	.21 ± .052	2.6 ± .65	—	—	.38 assumed	—	7.61 ²
<i>C.r. jochelsoni</i> ...	E. Siberia (12)- Behring I. (3)	Chiefly winter	15	6.6-7.8	7.19 ± .093	.36 ± .066	5.0 ± .92	.51	.57 ± .29	.33 ± .152	.33	7.51 ± .172
First year mice												
New subspecies...	Tuktoyaktuk.....	Sept.-Nov.	77	5.7-7.3	6.53 ± .036	.31 ± .025	4.7 ± .38	.69	.84 ± .12	.36 ± .045	.23	$\bar{x}=22.5$ 6.83 ± .045
<i>C.r. dawsoni</i>	Aklavik.....	Sept.-Nov.	66	6.4-7.8	7.09 ± .038	.31 ± .027	4.3 ± .38	.57	.65 ± .13	.34 ± .062	.26	7.00 ± .036
<i>C.r. dawsoni</i>	Southwest region.....	June-Nov.	22	5.9-7.6	7.04 ± .087	.41 ± .062	5.8 ± .87	.87	1.31 ± .23	.35 ± .046	.21	7.05 ± .046
<i>C.r. washburni</i> ...	Perry R.-Aylmer L.....	Aug.-Sept.	13	6.6-7.6	7.09 ± .073	.26 ± .052	3.7 ± .73	.54	.60 ± .14	.25 ± .118	.24	6.93 ± .101
Second + first year mice												
New subspecies...	Tuktoyaktuk.....	Sept.-Nov.	10+77	5.7-7.6	6.62 ± .042	.39 ± .030	5.9 ± .45	.83	1.19 ± .11	.41 ± .030	.22	6.87 ± .030
<i>C.r. dawsoni</i>	Aklavik.....	Sept.-Nov.	8+66	6.4-8.5	7.19 ± .050	.43 ± .035	5.9 ± .49	.77	1.01 ± .12	.43 ± .043	.28	6.98 ± .038
<i>C.r. dawsoni</i>	Southwest region.....	June-Sept.	40+17 ³	5.9-8.5	7.49 ± .063	.47 ± .045	6.3 ± .60	.86	1.28 ± .14	.40 ± .033	.25	7.11 ± .046
<i>C.r. jochelsoni</i> ...	E. Siberia (57)- Behring I. (3)	Chiefly winter	15+45	6.4-7.8	6.93 ± .048	.37 ± .034	5.3 ± .49	.67	.81 ± .14	.38 ± .055	.28	6.69 ± .050

¹ 10 specimens.

² 4 specimens.

³ Norman Wells specimens omitted.

measurements show a greater difference when the condylobasal minus diastema length is used as the independent variate. Rausch (1950) considered that palaeartic specimens of *C. rutilus* had a slightly shorter and lighter rostrum than Alaskan material; but the diastema length of second year *C.r. jochelsoni* agrees with that of *C.r. dawsoni* rather than with that of the Tuktoyaktuk series. However, the regression line of the combined first and second year series of *C.r. jochelsoni* lies considerably lower, indicating that the diastema of the first year series alone might be relatively short.

Nasal length (Table XII, Figures 13, 21). The proximal end of the nasals of *C. rutilus* may be rounded or square¹, or may have a small central extension. The latter, when present, was always included in the measurements. The nasals, like the diastema, are apparently one of the last parts of the skull to attain adult size (See under *Diastema* for argument), and this may be considered additional proof that the whole front portion of the skull is involved in the late growth. However, the relative positions of the regression lines in Figure 21 are quite different from those in Figures 19 and 20. The southwest region population has the largest nasals relative to condylobasal length; the barren ground and Siberian populations, the smallest. The 36 specimens from northern Alaska measured by Rausch (1950) also have relatively small nasals (mean condylobasal length, 23.60 mm., nasal length, 7.15 mm.). Further information from the palaeartic or from other specimens is needed to judge if this may be an adaptation to northern habitat.

GENERAL SUMMARY

Two hundred and six specimens of *C. rutilus* were taken at Tuktoyaktuk, Aklavik, and Norman Wells between September 21 and 29, 1951, and between October 2 and November 24, 1952.

The best criterion for estimating the age of *C. rutilus* is the extent of molar rooting. In mice with no external evidence of rooting, the reduction of the alveolar capsule is helpful. An estimated 95 per cent of the young of the year may be correctly separated from second year mice by these criteria. A very few mice may survive part or all of a second winter, but probably die before midsummer.

Under natural conditions, the young of *C. rutilus* are probably born from early May until early September. Some living in heated dwellings perhaps bear young throughout the winter. The first known record for nestlings is June 3 (Reindeer Station); the first record for trapped young, June 11 (Canol Road). The last record of a pregnant female is August 16, also on the Canol Road. A skin showing enlarged mammae was taken at St. Michael, Alaska, on September 8.

Pregnancy probably occurs frequently at post partum oestrous, and a single female could have four or five litters per season. However, the bimodal distribution of condylobasal length of the Tuktoyaktuk and Aklavik 1951 and 1952 specimens suggests only two litters per female at those places and in those years, or at least an interruption in breeding prior

¹ Bailey (1897) is incorrect in saying that the nasals of *C.r. dawsoni* are never truncate.

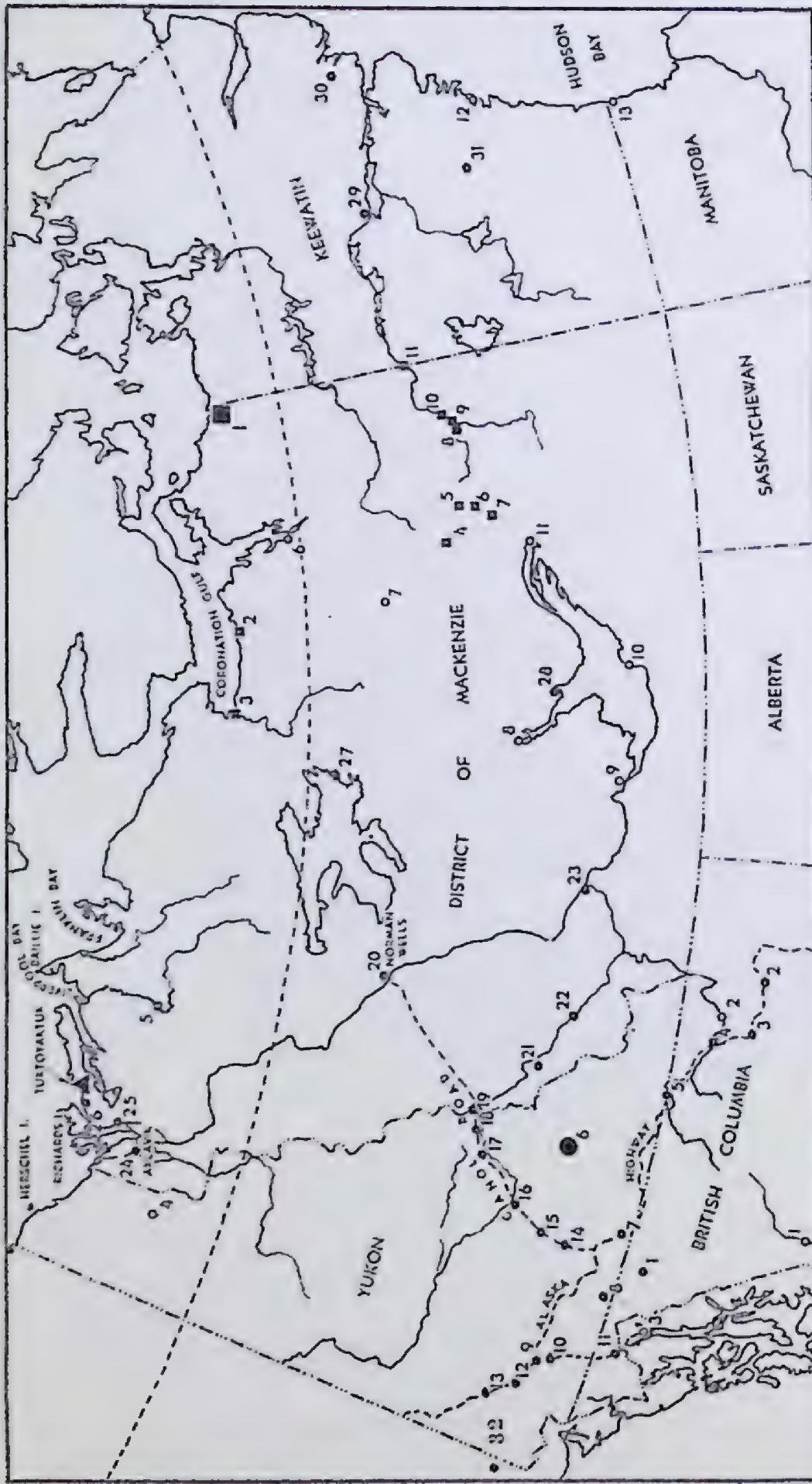


Figure 14. The solid circles, squares, and triangle indicate the places whence the specimens seen were taken. The numbers are given in heavy type in the list of specimens examined. ● = *C. r. dawsoni*, ▲ = new subspecies, ■ = *C. r. washburni*. The large symbols show the type regions. The places marked 1 to 23 of *C. r. dawsoni* are included in the southwest region. The open circles show marginal and other records referred to in the text. These are: 1, Stikine River, Lat. 57° 30'; 2, Hells Gate; 3, Haines; 4, La Pierre House and Porcupine River; 5, Fort Anderson, and Anderson River; 6, Bathurst Inlet (Banfield 1951); 7, Contwoyto Lake (Banfield 1951); 8, Fort Rae; 9, Fort Providence; 10, Fort Resolution; 11, Fort Reliance; 12, Mistake Bay (Sutton, 1931, p. 155); 13, Nunalla.

Bathurst Inlet is clearly, and Contwoyto Lake probably, within the range of *C. r. washburni*. The Fort Providence record may be based on misidentification of *C. gapperi* specimens (see footnote p. 58). Fort Anderson is probably within the range of *C. r. dawsoni*, but the range of the new subspecies might extend that far east, or the range of *C. r. washburni* possibly that far west. The remainder are records of *C. r. dawsoni*.

to the final pregnancy. The 'early' (first ?) Tuktoyaktuk litters had a mean condylobasal length of 94 per cent of adult length; the early Aklavik litters, 93 per cent of adult length. At Tuktoyaktuk, a significantly larger proportion ($\chi^2 = 11.9$, $n = 2$, $P < .01$) of 'late' (second ?) litter mice were caught between October 6 and 17, 1952, than before or after these dates. It is thought that the bad weather prior to October 6 and the deeper snow after October 18 may have prevented the younger mice from foraging far afield on the surface.

Growth, as measured by condylobasal length, is interrupted during the winter, perhaps owing to a decrease in food supply. It is thought that in some individuals this interruption may occur as early as July, but only after they have reached about 94 per cent of adult size. It is suggested that, if the interruption is not directly caused by a delay in sexual development, at least there may be a connection between the two phenomena. In the collections examined, large first year females outnumber large first year males, and the latter may more rarely reach sexual maturity in their first year. Out of 37 pregnant or parous females, five are almost certainly first year mice, and four are possible first year mice. Of the former, the earliest taken was lactating on August 17; of the latter, the earliest was lactating on July 15.

The mean number of young, embryos, or placental scars in 28 counts is $5.93 \pm .23$. This count is higher than in two related species living in more equable climates.

The 1951 and 1952 collections consisted of 103 males and 102 females. Collections from the three places in the two years, considered separately, did not vary significantly from 50 per cent, but after the deeper snow came at Tuktoyaktuk on October 19, 25 out of 36 specimens were male (adjusted chi-square = 4.7). This probably indicates that males were more inclined to wander above the snow than females.

The unworn juvenal peltage, as well as subadult peltage, closely resembles that of the summer adult, but when worn, the juvenal peltage becomes dark and dull. Even within a single population there is considerable variation in the size and probably the age at which the juvenal moult occurs. There seems to be no second subadult moult, and sometimes the first, or juvenal, moult is replaced by an autumn moult into winter peltage. The autumn moult usually occurs between late September and late October, but the winter peltage may continue to grow through November.

There does not appear to be a regular spring moult; the darker summer peltage is gained by gradual growth of some dark hairs and shedding and wear of the pale winter fur. Some individuals may have a more complete spring moult in patches. June skins of second year mice are more yellow about the face and sides than those of second year mice in July and August, probably because of the retention of winter hair. Individual variation in dorsal colour is slight in summer peltage but apparently distinctly greater in winter. The dorsum of winter skins is less red, more buff, or more grey than summer skins; the sides and face are more buff and less grey. Only three out of 441 skins are dark-phased. One specimen from Aklavik has a Snuff Brown dorsum and no pronounced stripe.

There is a cline, possibly stepped, with local variations in populations, of decreasing buffness of the under parts from southeast to north, northeast, and perhaps northwest. In a short-lived cyclic species an understanding

of the complexities of absolute and relative growth is essential to a sound interpretation of inter-population comparisons. Condylbasal length was taken as an indication of body size and was used as the independent variate for determining the relative size and growth of the other skull measurements, using the linear regression formula, which was considered sufficiently accurate over the short range of measurements available.

The coefficients of variation for both adults (second year mice) and the total active population (first and second year mice) are considered lower than in most mammals.

No evidence was found to indicate that the means of the skull measurements taken varied with sex, although there may be more variability in females.

Skull depth is a useful measurement for population comparisons, since there is only a slight increase with age. The populations examined show some significant differences in the regression coefficients which may be associated with the age of the specimens and the season at which they were taken.

The mean zygomatic breadth of autumn and winter first year specimens adjusted to a common condylbasal length is greater than that of summer first year specimens. This indicates that growth across the zygoma continues through the winter. There may also be some increase in this dimension into old age. Lambdoidal breadth is probably closely correlated individually with zygomatic breadth, and there is evidence that it also increases during the winter, when there is comparatively little growth in condylbasal length.

After the molars have rooted, the crown length of the mandibular tooth row eventually becomes shortened by wear. Ideally, all specimens with evidence of rooting of the upper molars should be eliminated from the calculations, and it is essential that at least those specimens with very worn lower molars should be discarded. There appears good evidence of a marked increase in the length of the mandibular tooth row during the autumn and early winter, after which the increase is small.

Increase in condylbasal length is due mainly to lengthening of the diastema and forward part of the skull. Under natural conditions, there is comparatively little increase in diastema length during the winter. Growth recommences in spring and may continue through June. Possibly the diastema of mice living in heated houses continues to grow throughout the winter, or recommences growth abnormally early in the spring.

The nasals, like the diastema, are apparently one of the last parts of the skull to cease growing, and this further indicates that the whole front portion of the skull is concerned in this late growth. There is some indication that the more northerly populations have relatively shorter nasals.

TAXONOMIC SUMMARY

Clethrionomys rutilus platycephalus (new subspecies)

Type. N.M.C. 20860. Second year male. Collected October 14, 1952, by T. H. Manning. Field number, K 280. Skin and skull in good condition. *Measurements.* Total length, 140 mm.; tail, 32 mm.; hind foot, 19 mm.; condylbasal length, 23.3 mm.; skull depth, 8.5 mm.; zygomatic

breadth, 13.5 mm.; mastoid breadth, 11.4 mm.; crown length of maxillary tooth row, 4.7 mm.; diastema length, 7.1 mm.; nasal length, 7.5 mm.

Type locality. About eight miles south of Tuktoyaktuk, Mackenzie District, Northwest Territories, about latitude $69^{\circ} 22'$, longitude $133^{\circ} 05'$. Under one hundred feet altitude.

In view of the possible growth of Tuktoyaktuk as a transportation centre, with the consequent increased opportunity for the introduction of mice from Aklavik and other points up the Mackenzie, the advantage of selecting a type from outside the settlement seemed to outweigh some other disadvantages. The 12 skins and 16 skulls (mean condylobasal length, 21.44 mm., mean skull depth, 8.26 mm. of 14 first year mice) taken 8 miles south of Tuktoyaktuk do not differ in the diagnostic characters from the larger series obtained at the settlement, and the whole series has been used in the following diagnosis.

Diagnosis. *Skins.* *Winter and summer:* 43 ± 5 per cent of known population have completely white underparts (Table IV), but this white usually less bright than in *C.r. washburni*. Yellowish moustache patch usually well developed; sometimes some white in lower part of cheeks but usually less than in *C.r. washburni*. *Summer peltage:* True summer peltage unknown. September and early October skins, apparently not moulting or just beginning to moult, are variable but average darker and greyer than comparable *C.r. dawsoni*, especially than those from Aklavik. Also darker and greyer than topotypical summer *C.r. washburni*. Less easily distinguishable by this character from Clinton-Colden-Aylmer Lake population of that race. Facial greyness intermediate between *C.r. dawsoni* and Clinton-Colden-Aylmer Lake population of *C.r. washburni*, but probably closer to former, although occasionally inseparable from latter. *Winter peltage:* Dorsum, Hazel to Bister. Averages greyer and darker than that of *C.r. dawsoni* from Aklavik (about 80 per cent separable by greyness) and Norman Wells. Also much greyer and darker than that of *C.r. jochelsoni*, including topotypes from Verkhne Kolymsk, and perhaps than *C.r. washburni* (six Coronation Gulf specimens). *Skull:* Smallest of the three Canadian races of *C. rutilus* in all measurements taken. Lightly constructed, with poorly developed ridges even in old mice. Post-palatal bridge perhaps even weaker and less likely to be complete than in *C.r. dawsoni*. Mice of all ages best separated (about 90 per cent of specimens) from *C.r. washburni* and *C.r. dawsoni* by flatness of skull when measured through cranium and bulla. First year specimens 88 per cent separable when measurements adjusted to a common condylobasal length (Figures 7 and 15). In this character *C.r. platycephalus* resembles *C.r. jochelsoni* from east Siberia more closely than neighbouring Canadian races. *Body measurements of 10 second year specimens:* total length, 136.4 mm. (130 mm.–142 mm.); tail, 31.8 mm. (29 mm.–36 mm.); hind foot, 18.8 mm. (17.5 mm.–19.5 mm.).

Range. Known only from Tuktoyaktuk and southward for about eight miles but probably occupies the barren grounds eastward at least to Liverpool Bay. Skins believed to come from Kittigazuit, 18 miles away, are tentatively referred to *C.r. dawsoni*.

Clethrionomys rutilus dawsoni (Merriam)

¹*Evotomys dawsoni* Merriam (1888, p. 650).

Evotomys alascensis Miller (1898, p. 364).

Clethrionomys rutilus dawsoni (Merriam). Rausch, 1950.

Type. N.M.C. 92. First year. Unsexed. Collected June 23, 1887, by G. M. Dawson. Mounted skin. Skull badly smashed.

Type locality. Finlayson River, Yukon Territory. Lat., 61° 30' N., Long., 129° 30' W., altitude, 3,000 feet.

Diagnosis. *Skins. Summer and winter pelage.* Hair of underparts usually buff-tipped. Proportion of entirely white-bellied specimens increases toward north and probably to east with some local variations (Table IV). White of throat does not normally extend up sides of face. Yellowish (Cinnamon Buff) moustache patch well developed, usually bordered with Buckthorn Brown in summer, paler and usually rather less conspicuous in winter. *Summer pelage:* Dorsal stripe Chestnut. Sides and face usually more yellow (Buckthorn Brown), less grey, than in the other two Canadian races. Specimens from Aklavik, Port Radium, Yellowknife, perhaps (See Banfield, 1951) Fort Reliance, and Victory Lake may average more yellow than those from southwest region nearer type locality. *Winter pelage:* Specimens seen from Aklavik and Norman Wells only. Sides and face paler, more buffy than in summer. Dorsum paler, less 'red', and more variable; in Aklavik series, varies from Cinnamon or Orange Cinnamon to Snuff Brown. Smaller Norman Wells series averages less 'grey', and Aklavik population may be exceptionally variable (Table III). *Juvenal pelage:* At first similar to adult, but before moult fur becomes grizzled and dull on the dorsal surface, and more grey on sides and bellies as more of the under fur shows through. These worn juvenals average paler than comparable *C.r. washburni*, and probably paler than comparable *C.r. platycephalus*. *Skull:* Post-palatal bridge weak, usually incomplete, except in some older mice. Skulls of adults (second year mice) intermediate in size between *C.r. platycephalus* and *C.r. washburni*, approaching size of latter in most measurements (See Tables, Figures) toward north (Aklavik and Caribou Hills) and also probably on eastern barrens (Victory and Smoke lakes), but no full-grown specimens seen from latter region. Most readily separated from *C.r. platycephalus* by greater depth of skull measured through bulla, and from *C.r. washburni* (second year specimens only) by smaller crown length of maxillary tooth row.

Range. All Yukon Territory, except perhaps extreme north, where it may be replaced by *C.r. platycephalus*. British Columbia: south on the Haines Road to Mile 85, and to about latitude 57° 30' on the Stikine River (Swarth, 1922; see also Allen, 1903b; Orr, 1945), to Summit Pass on the Alaska Highway (Cf. Rand, 1944; Baker, 1951), and to Hells Gate on the Liard River (Allen, 1903b). Mackenzie District from Aklavik, Caribou Hills, and possibly Kittigazuit in the northwest; south at least to Virginia Falls and Fort Simpson (Cf. Hanson, 1952), and probably to the British Columbia boundary (See Allen, 1903b); east at least to Port Radium and

¹No attempt has been made to give a full synonymy for this race.

Yellowknife, and probably (Banfield, 1951) to Fort Reliance; also recorded at Fort Providence and Fort Rae (Preble, 1908) and Fort Resolution (Coues, 1877¹). In the northeast, specimens from Fort Anderson and the Anderson River (Coues, 1877) are probably referable to this race. However, it is possible that some actually came from Liverpool Bay and Franklin Bay, which may be within the range of *C.r. platycephalus*. Franklin Bay might be within the range even of *C.r. washburni*. Keewatin District from Baker Lake in the northwest, at least to Smoke Lake in the northeast; south at least to Victory Lake, probably to (and possibly within) the tree-line in the west. On the Hudson Bay coast south to the Manitoba boundary, and to Nunalla (= Nonala, Breckenridge, 1936), where a single specimen has been taken. The Keewatin and the Mackenzie District populations probably connect along the 62nd parallel, although possibly they may be separated by the southern part of the range of *C.r. washburni*. In Alaska, south at least to Haines (Baker, 1951), and west from the Yukon boundary to Behring Strait and north to Point Barrow, i.e., covering all Alaska except parts of the Pacific coast region, where the species is represented by other races (See Orr, 1945).

Clethrionomys rutilus washburni Hanson

Evotomys dawsoni Merriam. Allen, 1910; Seton, 1911, p. 344 (in part).

Clethrionomys dawsoni dawsoni (Merriam). Anderson, 1930, p. 112 (in part), Clarke, 1938, p. 38 (in part), Anderson, 1947, p. 154 (in part).

Clethrionomys rutilus dawsoni (Merriam). Banfield, 1951 (in part).

Clethrionomys rutilus washburni. Hanson, 1952, p. 500.

Type. C.M.N.H. 72939 (Philip Hershkovitz *in litt.*). Taken July 2, 1949 (Hanson, 1952). Adult male. Skin and skull. Not seen.

Type locality. Perry River, Mackenzie District, Northwest Territories. Latitude, 67° 34' N., longitude, 102° 07' W. (Hanson, 1952). This is about fifteen miles from the river mouth (Hanson *et al.*, 1956).

Diagnosis. *Skins.* *Summer and winter pelage:* Hair of underparts tipped with white in all 49 skins examined. This hair usually brighter than in the white-bellied specimens of *C.r. dawsoni* and *C.r. platycephalus*. White of throat extends up side of face to level of nostrils or above. Yellow moustache patch reduced or absent. *Summer pelage:* Dorsal stripe similar to that of *C.r. dawsoni*. Proportion of grey and buff on face and sides of topotypical *C.r. washburni* similar to that on *C.r. dawsoni*, but specimens from Clinton-Colden and Aylmer lakes distinctly darker and greyer. *Winter pelage:* Known only from six Coronation Gulf specimens, which is possibly toward western extremity of range of *C.r. washburni*. Four closely match the Cinnamon Aklavik skins of *C.r. dawsoni*; two nearer the Hazel skins of *C.r. platycephalus*. *Skull:* Largest and most heavily constructed of the three Canadian races. In adults, ridges usually well developed. Post-palatal bridge weak, and perhaps less likely to be complete than in *C.r. dawsoni*. Skulls of second year specimens are notably broad, particularly across the zygoma (Figures 8, 16). In second year specimens

¹Preble (1908) obtained only *C. gapperi* at Fort Resolution, and he and later authors appear to have ignored the four specimens from there listed as *C. rutilus* by Coues, the correctness of whose identification has not been checked.

unadjusted and adjusted crown length of maxillary tooth row long, but adjusted length in first year mice does not differ from that of comparable *C.r. dawsoni* (Figures 10, 18). Nasals long only by virtue of large general skull size (Figures 13, 21); shorter relative to condylobasal length than in *C.r. dawsoni*, particularly near-topotypes.

Range. From Perry River in the northeast, westward to Coppermine and south to Aylmer Lake, Artillery Lake, and Thelon Game Sanctuary. Possibly bisecting the range of *C.r. dawsoni*.

TAXONOMIC DISCUSSION AND ORIGIN OF THE CANADIAN RACES

Rausch (1950) considered that the similarity of the skulls of *C. rutilus* and *C. dawsoni* and the wide overlap in pelage colour between populations of the palaeartic and nearctic forms justified their inclusion in a single species. He observed that his Alaska material showed a slightly heavier and longer rostrum, although this character was variable, longer nasals, and a slightly greater arching of the cranium. Actually, when allowance is made for the greater condylobasal lengths of his Alaskan specimens (See Figure 21), there is little difference in these nasal length measurements. There is, however, a distinct difference in the tooth row lengths of his nearctic and palaeartic series, and it may be noted that, whereas the mean he gives for *C.r. jochelsoni* agrees closely with the figure obtained for this paper (doubtless a number of the skulls were included in both series), his 36 Alaskan specimens have a decidedly longer average tooth row than those of any of the Canadian series given in this paper. Had Rausch extended his subjective observations on the cranial arching to actual measurements of skull depth, he might have hesitated to alter the established concept of a palaeartic and separate nearctic species without additional evidence. It is not, however, suggested that the difference in measurements is incompatible with a single race, or that the new concept of a single holoartic species, which has been accepted by subsequent authors, should now be reversed. Indeed, the difference in skull depth is in itself far from conclusive evidence of specific difference, for, assuming all Tuktoyaktuk specimens to be *platycephalus* and all Aklavik and Caribou Hills specimens to be *dawsoni*, there is an overlap of about 10 per cent between the two forms, with no indication from the pelage or other skull measurements of the anomalous individuals that this geographical division is not justified. That is to say, there is no evidence of two mainly allopatric species with occasional overlap of wandering individuals. The chief cause for doubting if the Tuktoyaktuk population and, by inference, the palaeartic populations, are conspecific with other American races is the sudden reversal in the Tuktoyaktuk population of the south to north cline of increasing (as measured by condylobasal length) size shown by *C.r. dawsoni* and *C.r. washburni*. Next to the similarity in skull depth, this reversal of the size cline, coupled with the similarity in size of *C.r. platycephalus* and *C.r. jochelsoni* is the most obvious evidence for the close relationship between these two races. There are, as shown by the figures, both similarities and differences in the other skull measurements of *C.r. platycephalus* and *C.r. jochelsoni*. Some of the differences are not significant, and others may in part be explained by the differences in the seasons at which the specimens were

Species

taken. Difference in peltage colour need not be seriously considered as a specific character in view of the racial and inter-racial variability.

Presuming that *C.r. platycephalus* is more closely related to *C.r. jochelsoni* than to other North American races, but that the Northern Red-backed Mice form a single holarctic species, the origin of the race, *C.r. platycephalus*, with its apparently very limited range, is rather mysterious, for there is no evidence of a trend toward the flat-headed form in the north Alaskan material examined for this paper or reported on by Rausch (1950). It is conceivable that *C.r. platycephalus* originated during the latter part of the last century or the early part of this from a few *C.r. jochelsoni* which were accidentally transported by whaling vessels from Siberia to the mouth of the Mackenzie. Since most whalers wintered at Herschel Island, the existence of *C.r. platycephalus* on that island would strengthen this hypothesis, although it might also have been introduced through Baillie Island, another wintering place. The main objection to this theory is that the mainland, if not Herschel and Baillie islands, must surely have been occupied already by *C.r. dawsoni*, and it is difficult to see, unless *C.r. rutilus* is a distinct species, how it could have become established without more modification by and intergradation with *C.r. dawsoni*. Even an allopatric species would have had to have considerable biological advantage to replace the established form.

A more acceptable hypothesis is that *C.r. platycephalus* is a remnant of a pre- or inter-glacial population of *C. rutilus*, which then occupied the whole species range but survived in a comparatively unmodified form only in an isolated refugium near its present range. This hypothesis will be strengthened if the subspecies range is found to be more extensive than is at present apparent. It is perhaps supported by Cowan's description (1951) of a new race of *Microtus pennsylvanicus* on Richards Island. As in the case of *Clethrionomys*, Cowan's race is separable from the Aklavik population (*M.p. drummondii*), and although he considered it arose during isolation on Richards Island, it is possible that it and *C.r. platycephalus* are survivals from the same refugium.

If *C.r. dawsoni* evolved during glacial times from a *jochelsoni-platycephalus* type ancestor, the division between *C.r. dawsoni* and *C.r. washburni* must have occurred later, for in most skull characters (note particularly skull depth, Figure 15), the latter is farther from this assumed ancestral form. It is true that resemblances in the peltage of *C.r. platycephalus* and *C.r. washburni* have been mentioned above, but in an animal so obviously variable (Cf. Rausch, 1950), these resemblances may be due either to chance or to parallel selection in a similar (barren ground) environment.

It is possible that the characters which distinguish *C.r. washburni* from *C.r. dawsoni* are of dual origin. Some, such as large size, relatively short nasals, white underparts, and white on the lower cheeks, may be the end result of a cline caused by the selective response to climatic conditions. Other characters, such as heavily ridged skull, long maxillary tooth row, and broad zygoma, may be dependent on the large size and may result from constant differential growth. The reduction of the yellow moustache patch is at least partly due to the increase of facial white. In a different category is the darkness and greyness of the face and sides of the Aylmer Lake-Canton-Colden Lake population. It is possible that there is some peculiarity of that area and of the Thelon Game Sanctuary, not found elsewhere within the species range (except perhaps at Tuktoyaktuk) which favours the

dark grey pellation. More probably this pellation is governed by a mutant gene which only occurred with sufficient pressure to become established in a limited area, possibly at a period when there was some geographical isolation, although there seems to be no geological evidence for this. If, as the similar darkness and greyness of *C.r. platycephalus* seems to suggest, there is an advantage in the dark grey form on the barrens, the character may now be gradually spreading by gene exchange. Judging from the specimens available, this greyness and darkness is best developed in the Clinton-Colden-Aylmer lakes region, and becomes more dilute toward the north, where the Perry River series is only slightly affected.

To the south and west, the two Yellowknife and four Port Radium specimens, as well as the three from Fort Reliance described by Banfield (1951), appear to indicate a rather sudden change to the yellow form, probably at the tree-line. The eastern barren ground specimens, particularly those from Victory Lake, are also distinctly yellow about the face and sides, and have an extremely well-developed buff moustache patch. It is possible that they represent a later invasion of the barren grounds by the species. Unfortunately, no second year specimens of the southeastern barren ground population have been seen, but it is thought that the full-grown mice may be large. It will be interesting to see if the skull characters are those of *C.r. washburni* which, as has been shown, are best developed in the adults.

The present collections indicate that on pellation colour (greyness and darkness) it might be possible to separate subspecifically the Aylmer-Clinton-Colden lakes series from the Perry River topotypes of *C.r. washburni*. However, without more knowledge of the barren ground populations, this would be unwise, since it seems that the Perry River population is merely an intergrade for some characters between the Aylmer-Clinton-Colden lakes population and the eastern barren ground population, while the latter does not, from the information available, differ materially from *C.r. dawsoni*, or at least not from the yellow-faced and yellow-sided population which may extend just within the tree-line from Fort Reliance to Aklavik, although apparently not including the Caribou Hills region.

SPECIMENS EXAMINED¹

(Skins)

C.r. dawsoni. **British Columbia**. 1, Atlin, 6+1 U.B.C.; Alaska Highway (2, Mile 104 = Summit Lake, 3; 3, Mile 165 = Muncho Pass, 1; 4, Mile 213 = Liard River, 2; 5, Mile 313 = Irons Creek, 1). **Yukon Territory**. 6, Finlayson River, 1 (type); 7, Teslin Post, 4; 8, Carcross, 2; 9, Haines Road Junction, 1; 10, Haines Road, Mile 85, 1; 11, Kathleen River, 4; 12, Kluane Lake, 2; 13, Burwash Landing, 1; Canol Road (14, Mile 40 = Nisutlin River, 7; 15, Mile 95 = Rose River, 4; 16, Mile 132 = Lapie River, 24; 17, Mile 222 = Sheldon Lake, 19; 18, Mile 249 = MacMillan River, 3; 19, Mile 285 = MacMillan Pass, 2). **Mackenzie District**. 20, Norman Wells, 15; 22, Virginia Falls, 1 A.M.N.H.; 24, Aklavik area (30 mi. S. of Aklavik, 2 U.B.C., 26 mi. S. of Aklavik, 3, Aklavik, 83, Campbell Lake, 1 U.B.C., Mackenzie Delta, 1, 9 mi. N. of Aklavik, 1; Peel River camp, 2); 25, Caribou Hills, 10 U.B.C.; Reindeer Station, 6+8 U.B.C.; 26, Tuktoyaktuk (= Kittigazuit: Porsild's collection), 26; 27, Port Radium, 5 R.O.M.Z.;

¹ Numbers in bold type refer to places on map.

28, Yellowknife, 2 R.O.M.Z. **Keewatin District.** 29, Baker Lake, 2; 30, Smoke Lake, 5; 31, Victory Lake, 8. **Alaska.** 32, Chitina Glacier, 12; Not shown on map, Teller, 1; St. Michael, 6 U.S.N.M.; Mt. McKinley Park, 3 U.B.C.; Point Barrow, 1 U.K.M.

C.r. platycephalus. **Mackenzie District.** Tuktoyaktuk, 94 (type and paratypes), including 12 from 8 miles south of settlement.

C.r. washburni. **Mackenzie District.** 1, Perry River, 7 (paratypes) C.M.N.H.; Coronation Gulf (2, Port Epworth, 3; 3, Coppermine, 3); 4, Aylmer Lake, 10 A.M.N.H.; 5, Clinton-Colden Lake, 3 A.M.N.H. + 7 R.O.M.Z.; 6, Kasba Lake = Ptarmigan Lake, 1 A.M.N.H.; 7, Artillery Lake, 3 + 2 A.M.N.H.; Thelon Sanctuary (8, Dickson Canyon, 1; 9, Thelon cabin, 3; 10, below Grassy Island, 4; 11, Deer Pass, 2).

C.r. jochelsoni. **East Siberia.** Kolyma River (Verkhne Kolymsk, 4 U.S.N.M. (topotypes); Nijni Kolymsk, 2 U.S.N.M.)

(Skulls)

C.r. dawsoni. **British Columbia.** 1, Atlin, 6 + 1 U.B.C.; Alaska Highway (2, Mile 104 = Summit Lake, 4; 3, Mile 165 = Muncho Pass, 1; 4, Mile 213 = Liard River, 2; 5, Mile 313 = Irons Creek, 1). **Yukon Territory.** 6, Finlayson River, 1 (type); 7, Teslin Post, 4; 8, Carcross, 2; 9, Haines Road Junction, 1; 10, Haines Road Mile 85, 1; 11, Kathleen River, 3; 12, Kluane Lake, 2; 13, Burwash Landing, 1; Canol Road (14, Mile 40 = Nisutlin, 8; 15, Mile 95 = Rose River, 3; 16, Mile 132 = Lapie River, 22; 17, Mile 222 = Sheldon Lake, 18; 18, Mile 249 = MacMillan River, 2; 19, Mile 285 = MacMillan Pass, 2). **Mackenzie District.** 20, Norman Wells, 13; 21, Glacier Lake, 9; 22, Virginia Falls, 1 A.M.N.H.; 23, Fort Simpson, 1 A.M.N.H.; 24, Aklavik area (30 mi. S. of Aklavik, 2 U.B.C.; 26 mi. S. of Aklavik, 2; Aklavik, 75 + 1 U.B.C.; Mackenzie Delta, 1 R.O.M.Z.; Peel River camp, 2); 25, Caribou Hills, 10 U.B.C.; Reindeer Station, 6 + 8 U.B.C.; 27, Port Radium, 5 R.O.M.Z.; 28, Yellowknife, 2 R.O.M.Z. **Keewatin District.** 29, Baker Lake, 2; 30, Smoke Lake, 5; 31, Victory Lake, 7. **Alaska.** 32, Chitina Glacier, 11; Not shown on map, Teller, 1; St. Michael, 6 U.S.N.M.; Mt. McKinley Park, 4 U.B.C.; Point Barrow, 1 U.K.M.

C.r. platycephalus. **Mackenzie District.** Tuktoyaktuk, 110 (type and paratypes), including 16 from 8 miles south of settlement.

C.r. washburni. **Mackenzie District.** 1, Perry River, 7 (paratypes) C.M.N.H.; Coronation Gulf (2, Port Epworth, 3; 3, Coppermine, 3); 4, Aylmer Lake, 10 A.M.N.H.; 5, Clinton-Colden Lake, 3 A.M.N.H. + 7 R.O.M.Z.; 6, Kasba Lake = Ptarmigan Lake, 1 A.M.N.H.; 7, Artillery Lake, 4 + 1 A.M.N.H.; Thelon Sanctuary (8, Dickson Canyon, 1; 9, Thelon cabin, 3; 10, below Grassy Island, 4; 11, Deer Pass, 2).

C.r. jochelsoni. **East Siberia.** Kolyma River (Verkhne Kolymsk, 22 U.S.N.M. (topotypes); Nijni Kolymsk, 40 U.S.N.M.); Kamtschatka (Petropaulski, 2¹; Behring Island, 3).

¹These and other specimens from the same locations were identified as *Evotomys vosnessenskii* by Miller (1898). They are, however, clearly referable to the species *C. rutilus*, and there seems no reason to doubt that they belong to the same race as the Verkhne Kolymsk and Nijni Kolymsk specimens (Cf. Ognev, 1950). According to Ognev (1950, p. 148), the confusion which involved Allen (1903a) and Hinton (1926) arose from Polyakov's description of *wosnessenskii*, which was based on a young specimen referable to the species *C. rufocanus*. Red-backed Mice were apparently introduced to Behring Island, presumably from the neighbouring mainland, about 1870 (Stejneger, 1884, p. 84).

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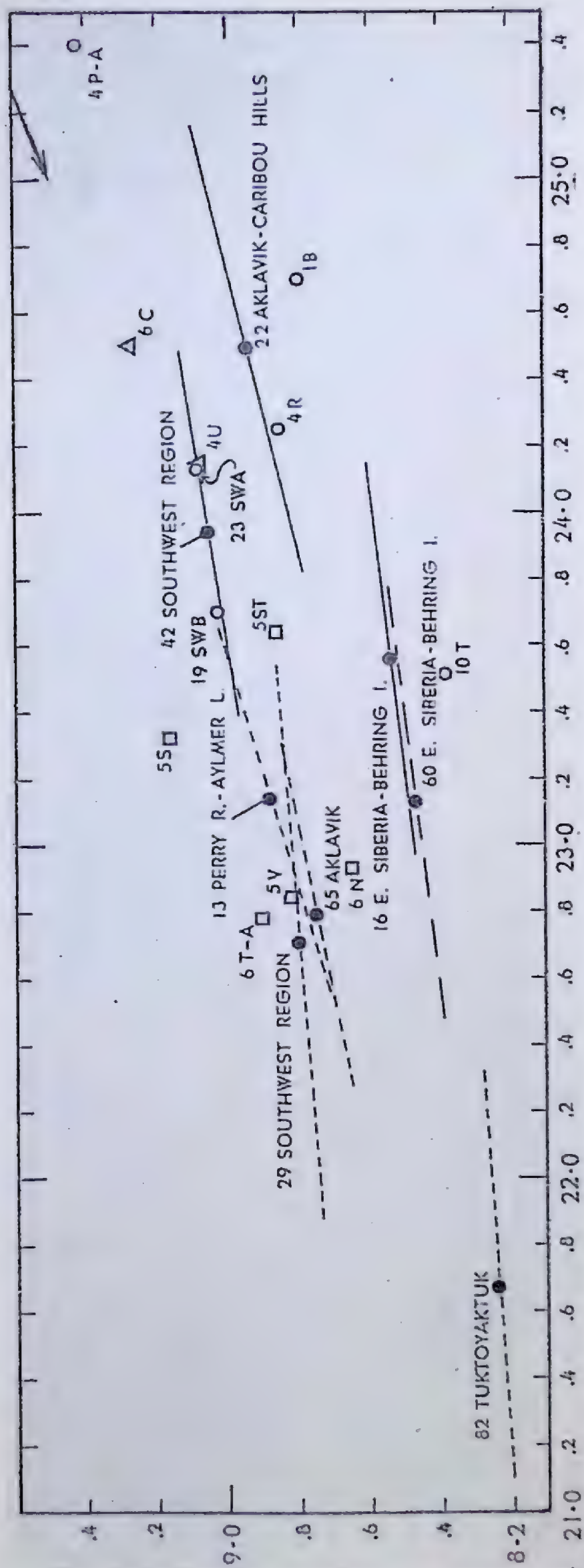


Figure 15. Regressions of skull depths on condylobasal lengths (abscissa) and mean skull depths of small collections plotted against mean condylobasal lengths.

The regression lines and some of the means are plotted from figures given in Table VI. The solid lines represent the regressions of second year series; the short broken lines, those of first year series; and the single line with long dashes, that of a mixed first and second year series. All lines extend either way from the mean (solid dot) for one standard deviation of condylobasal length measured along the abscissa. The squares represent means of first year mice; the circles, means of second year mice; the triangles, means of first and second year mice. One of the six Coronation Gulf specimens was probably in its second winter. A line representing the equal relative growth rate (i.e., the growth rates necessary to maintain the same ratio) for the Tuktoyaktuk series may be obtained by joining the dot representing the mean of that series to the arrow in the upper right corner of the graph.

B = Point Barrow (Aug. 29).

C = Coronation Gulf (Mar. 26-Aug. 26).

N = Norman Wells (Nov. 24)

P-A = Perry River-Aylmer Lake (including Clinton-Colden Lake, Ptarmigan Lake) (June 18-Aug. 31).

R = Port Radium (June 26-29).

S = Smoke Lake (Aug. 21-23).

ST = St. Michael (Sept. 4-9).

SWA = Southwest region (July 9-Aug. 31).

SWB = Southwest region (June 11-30).

T = Tuktoyaktuk (Oct. 2-c Oct. 23).

T-A = Thelon Sanctuary-Artillery Lake (July 17-Sept. 1).

U = Umiat (June 1-July 23).

V = Victory Lake (Aug. 12-14).

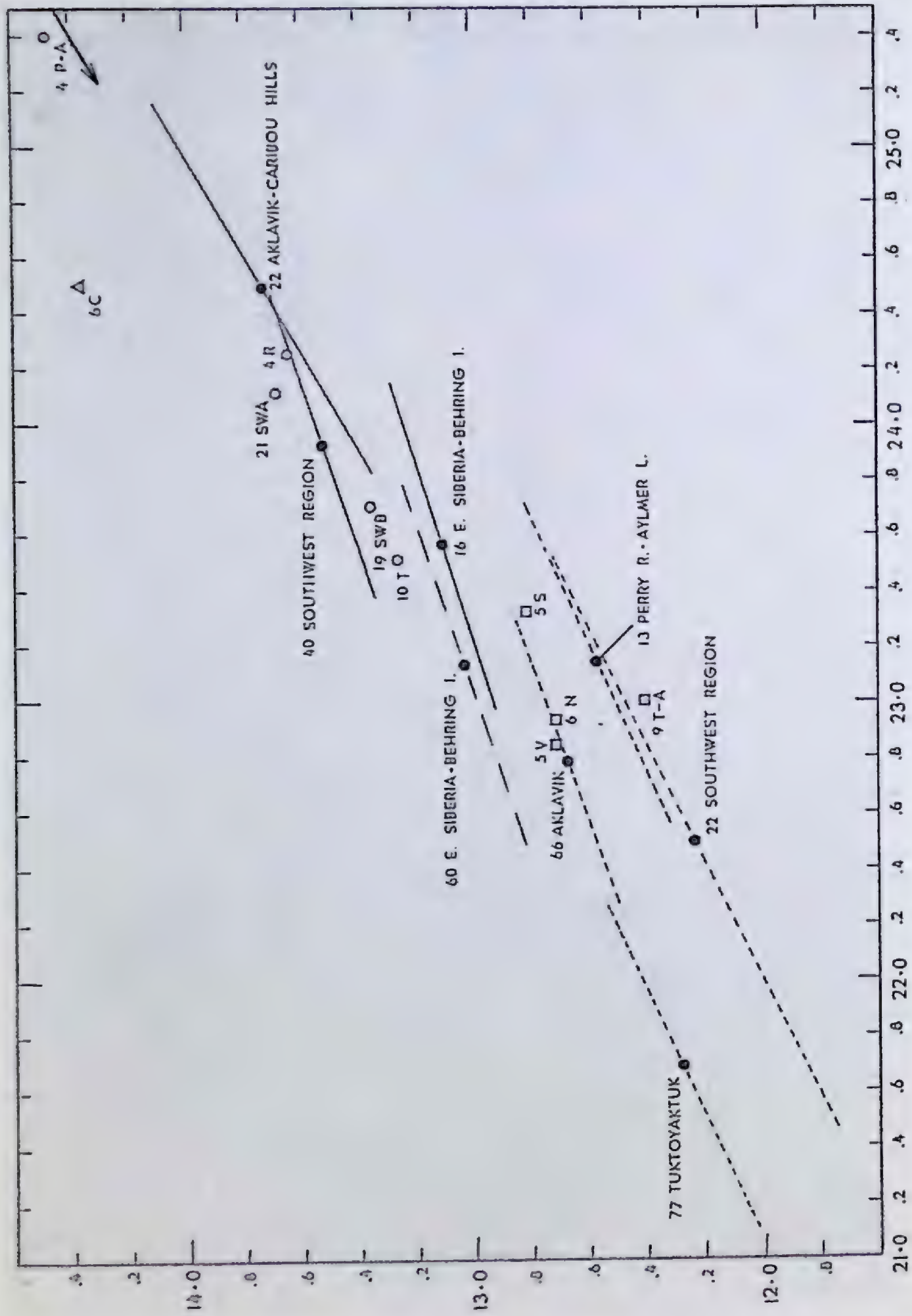


Figure 16. Regressions of zygomatic breadths on condylobasal lengths (abscissa) and mean zygomatic breadths of small collections plotted against condylobasal lengths. The regression lines and some of the means are plotted from figures given in Table VII. (See Figure 8 for explanation).

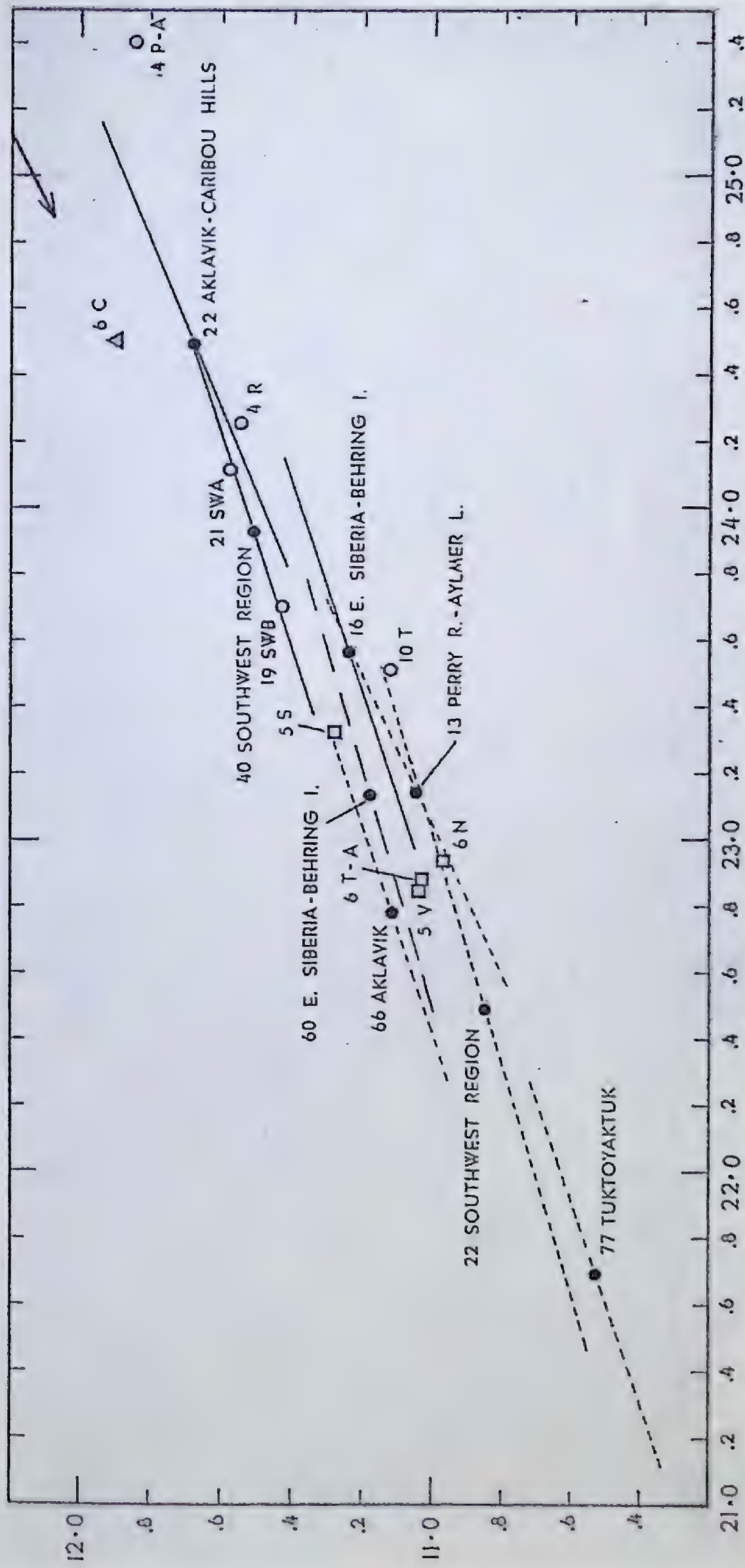


Figure 17. Regressions of lambdoidal breadths on condylobasal lengths (abscissa) and mean lambdoidal breadths of small collections plotted against condylobasal lengths.

The regression lines and some of the means are plotted from figures given in Table VIII. See Figure 8 for explanation).

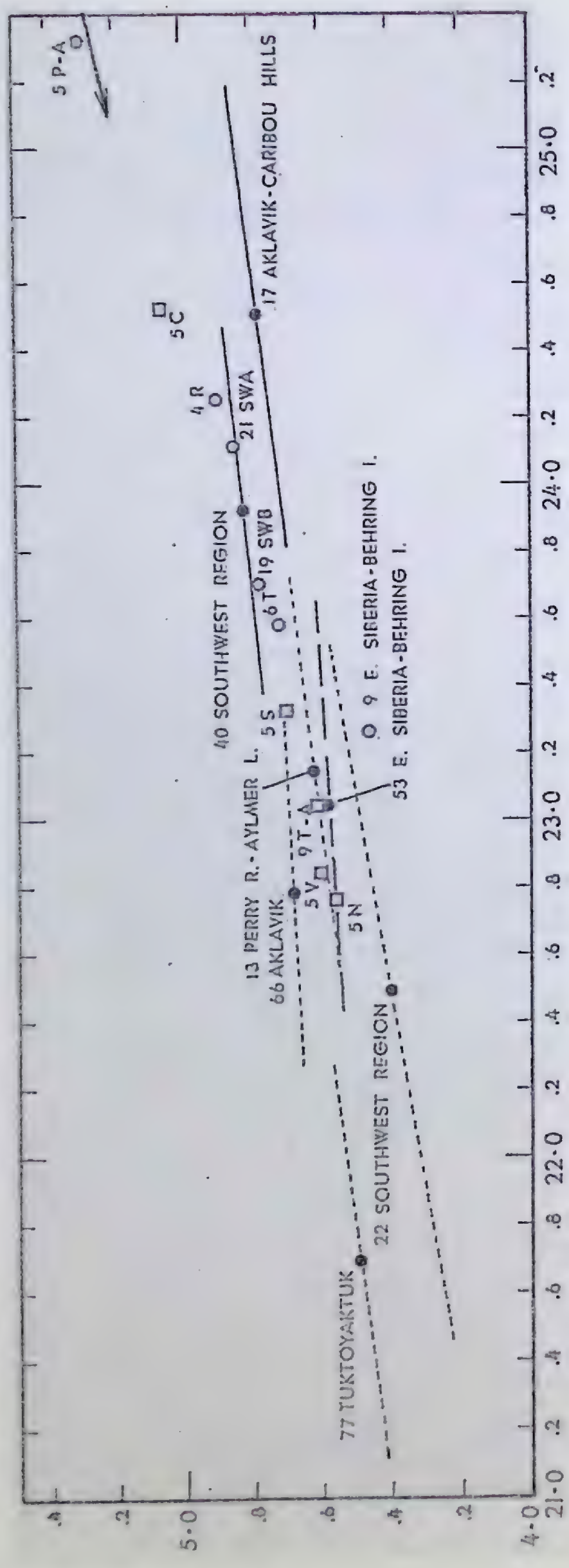


Figure 18. Regressions of maxillary tooth row lengths on condylobasal lengths (abscissa) and mean maxillary tooth row lengths of small collections plotted against condylobasal lengths.

The regression lines and some of the means are plotted from figures given in Table IX. (See Figure 15 for explanation).

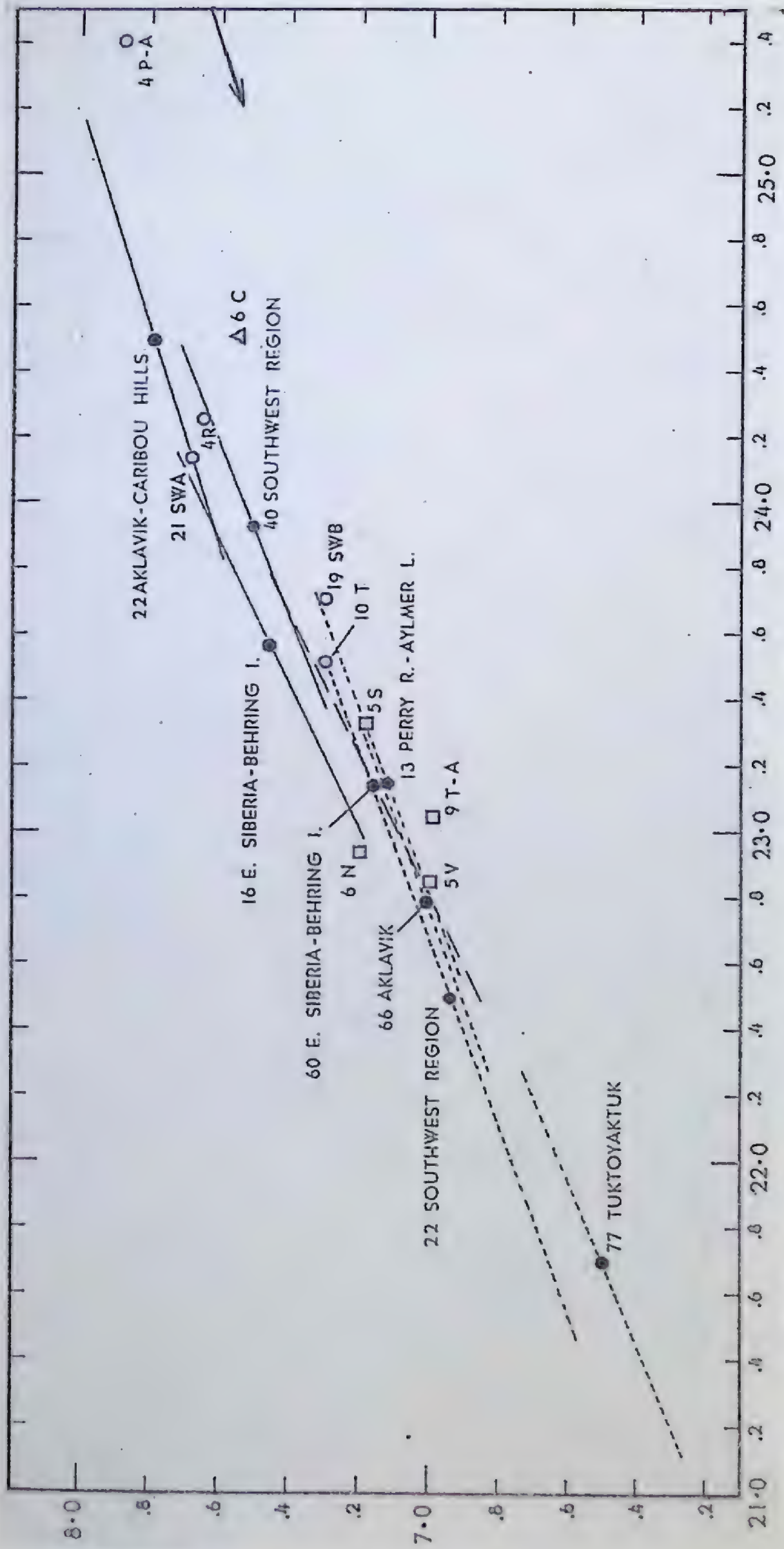


Figure 19. Regressions of diastema lengths on condylobasal lengths (abscissa) and mean diastema lengths of small collections plotted against condylobasal lengths.

The regression lines and some of the means are plotted from figures given in Table X. (See Figure 15 for explanation).

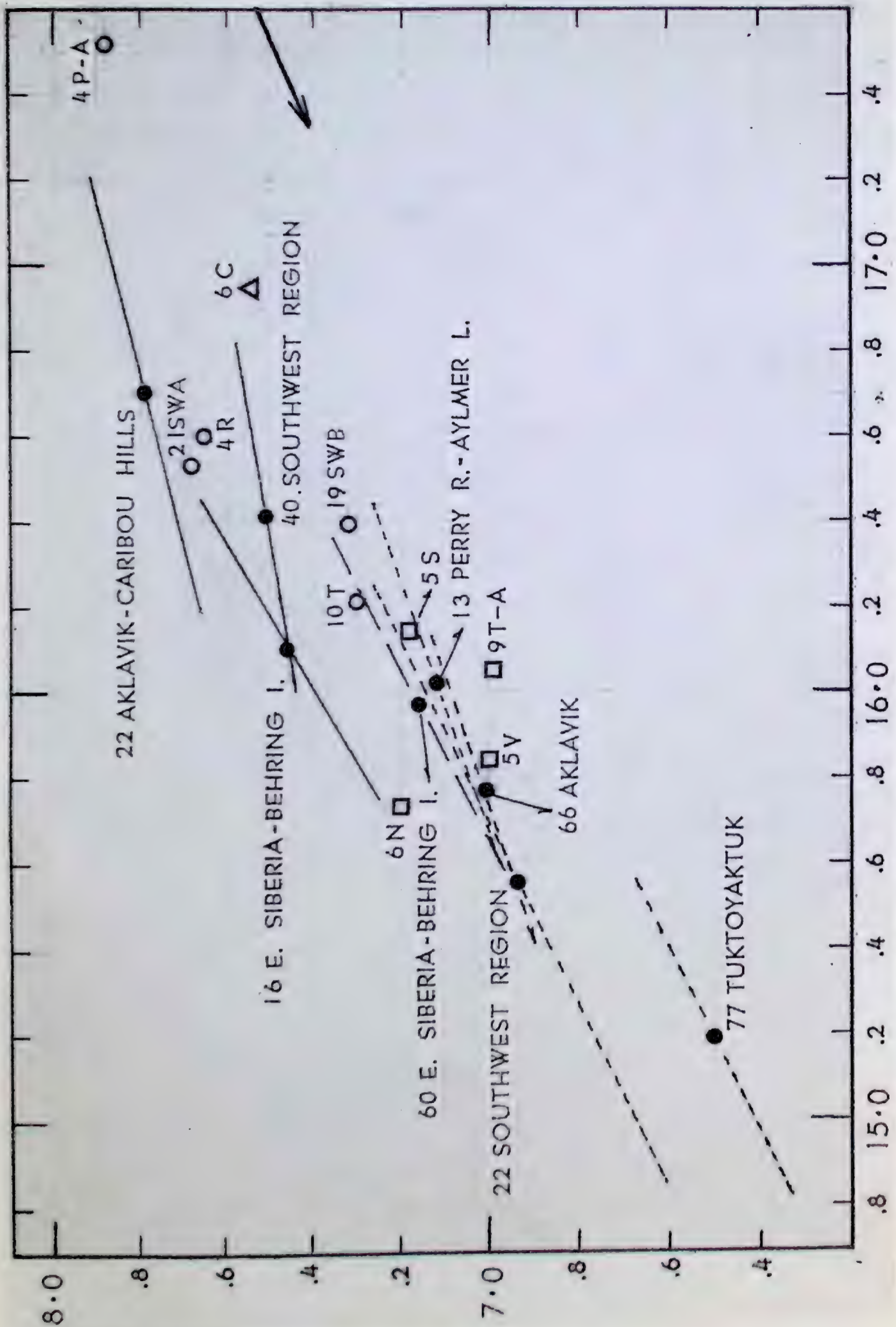


Figure 20. Regressions of diastema lengths on condylobasal lengths minus diastema lengths (abscissa), and mean diastema lengths of small collections plotted against condylobasal lengths minus diastema lengths.

The regression lines and some of the means are plotted from figures given in Table XI. (See Figure 15 for explanation).

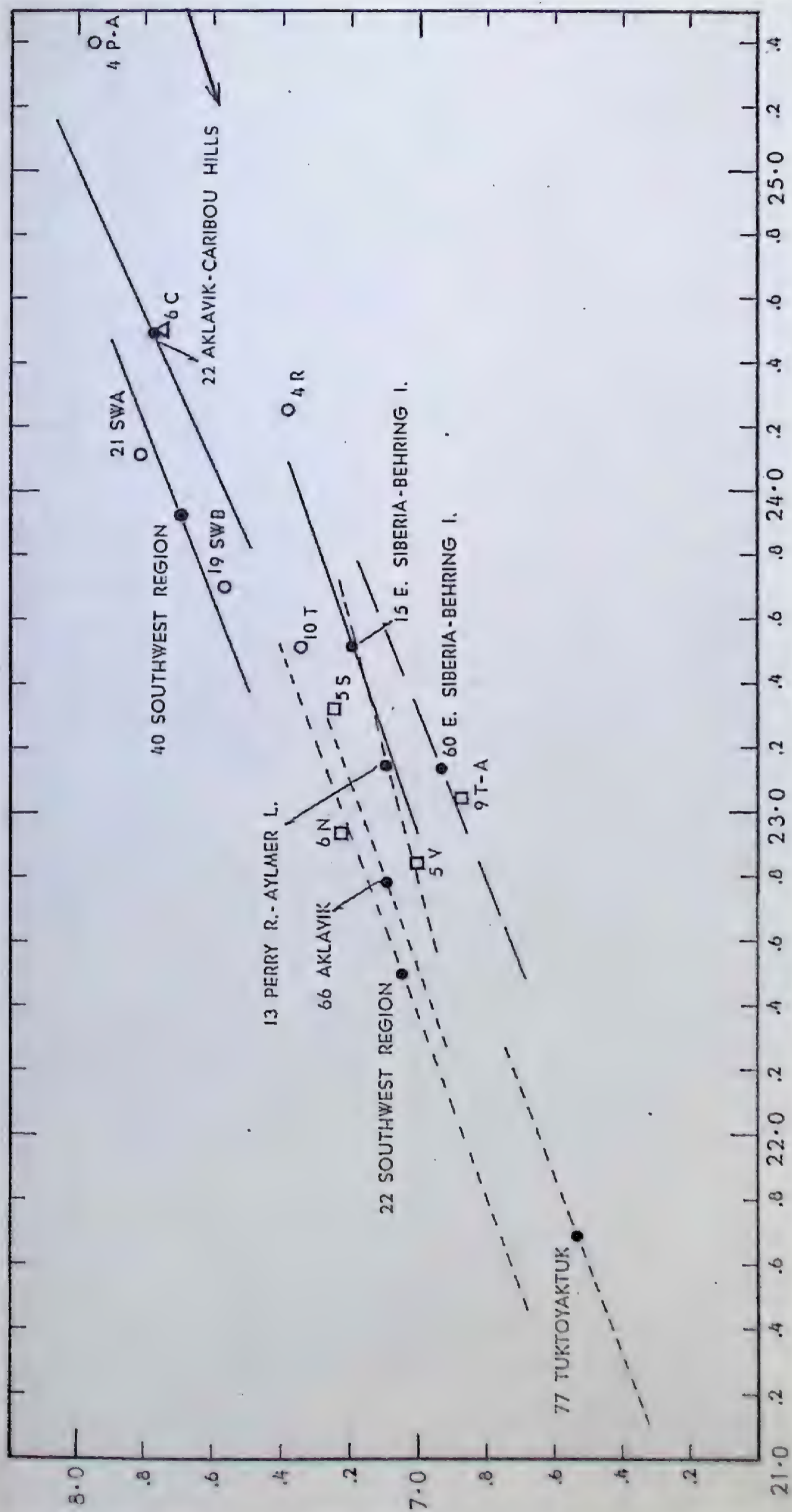
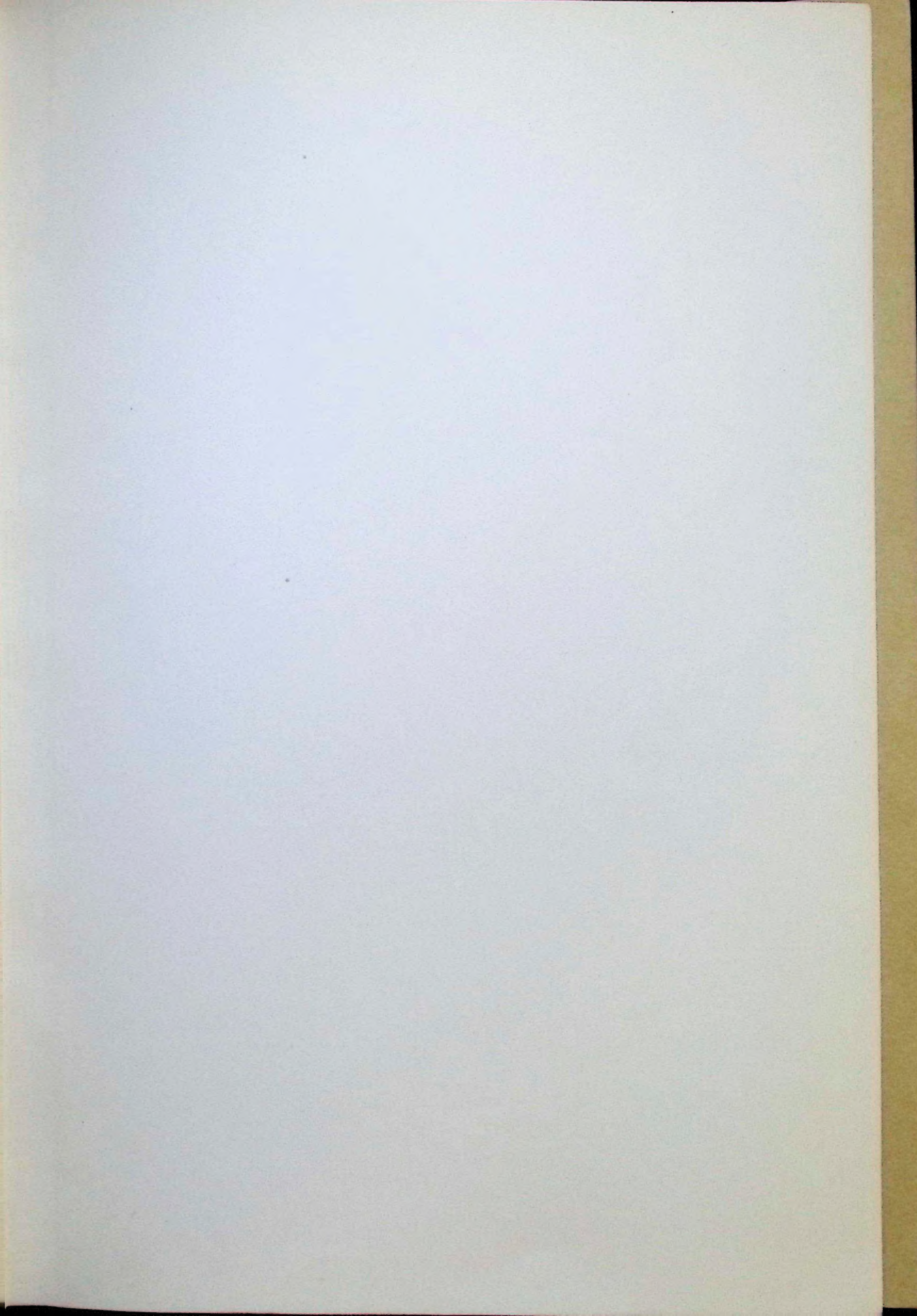


Figure 21. Regressions of nasal lengths on condylobasal lengths (abscissa) and mean nasal lengths of small collections plotted against condylobasal lengths.

The regression lines and some of the means are from figures given in Table XII. (See Figure 15 for explanation).





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